LABORATORY MANUAL

TO ACCOMPANY

CLARKE AND DENNIS'S

ELEMENTARY CHEMISTRY

BY

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PREFACE

THIS Laboratory Manual is designed to accompany the "Elementary Chemistry" by Clarke and Dennis, the numbers in brackets at the head of the experiments being those of the experiments as they occur in the text-book.

The chief benefits to be derived by the beginner in chemistry from a course in laboratory work are training in careful observation and accurate description and statement of experimental results, and practice in the neat and proper handling of apparatus. To aid and stimulate the development of the pupil's powers of observation, questions have been introduced under each experiment. The record of the student should not, however, be confined to the answering of those questions, but should comprise a full description of everything that he has observed.

As a guide to the pupil in the manipulation of apparatus, there have been inserted in the Manual numerous illustrations of the apparatus actually to be employed. With but few exceptions these illustrations have been drawn to scale, so that the pupil may know at a glance the relative sizes of the different parts. To insure more satisfactory results and to discourage careless work the amounts of the substances to be employed are given, and the student should be supplied with a graduated test tube and a cheap hand scale for measuring these amounts.

At the end of the Manual a few quantitative experiments have been introduced. With the exception of

Experiment 122, these are volumetric in character, and all of them may be performed with the graduated tube shown in Figure 42. With a balance accurate to ten milligrams results of satisfactory accuracy can be obtained. Such a balance may be procured for less than twenty dollars.

In the preparation of the list of experiments full consideration has been given to the recommendations of the Committee on College Entrance Requirements, the College Entrance Examination Board for the Middle States and Maryland, and the Committee of Ten on Secondary School Studies.

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LABORATORY MANUAL

PREPARATION OF APPARATUS

1. To cut a Small Glass Tube. — Lay the tube upon a table, moisten the edge of a triangular file, and with it make a fairly deep scratch across the tube. Grasp the tube in both hands with the thumbs on each side of the mark, but on the opposite side of the tube from the mark. Bend gently, pressing outward with the thumbs and pulling inward with the hands, and the tube will break at the point where the scratch was made.

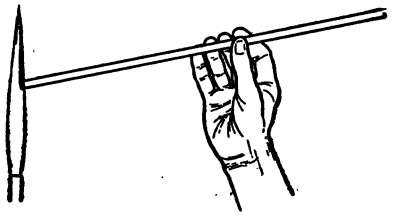

FIG. 1.

Smooth each end of the tube by holding it in the flame of the Bunsen burner and slowly rolling it backward and forward between the thumb and fingers (Fig. 1). Remove the tube from the flame as soon as the sharp edges of the end have become rounded; do not heat until they have even partly fallen together at the end.

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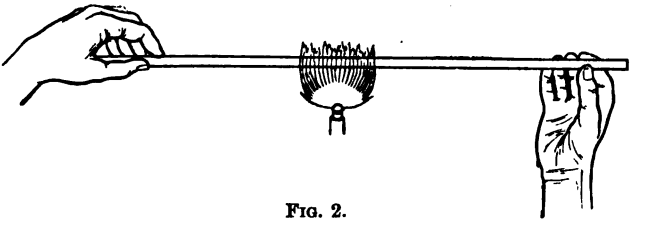
For bending tubes that are 6 mm. or less in outer diameter, the flame should be about 6 cm. across at its widest part. For larger tubes up to 10 mm. in diameter, use the full flame.



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Grasp the tube lightly between the thumb and fingers of each hand, the knuckles of the left hand being up and those of the right hand down (Fig. 2). Hold the tube lengthwise in the upper part of the flame and rotate the tube *slowly* and *constantly* by rolling it backward and forward between the thumb and fingers. Whenever glass is being heated in a flame, the glass should be kept in motion, but this motion need not be rapid.

When the glass tube has softened so that it will bend with ease, remove it from the flame and *then* bend it to the desired angle. Lay it aside to cool, but do not allow

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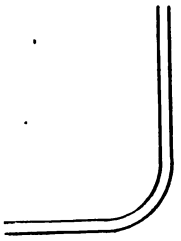

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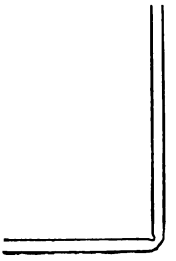

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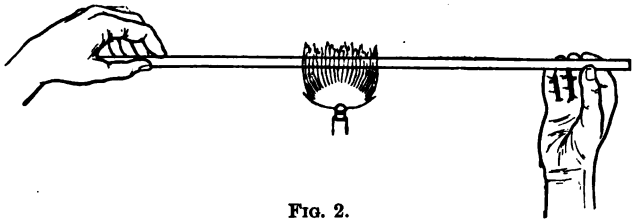

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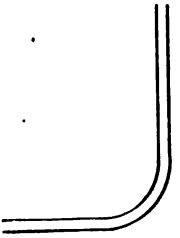

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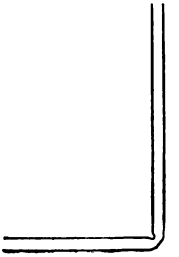

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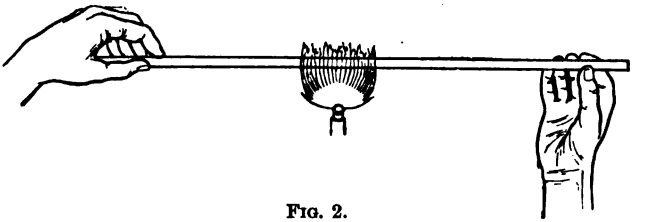

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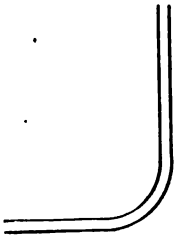

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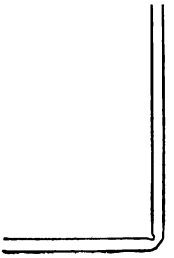

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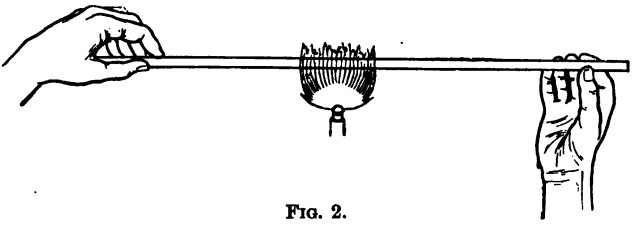

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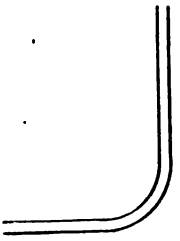

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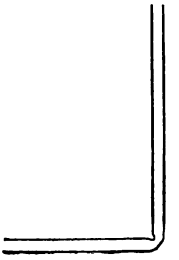

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the glass to thicken at the heated point. When the glass is quite soft, remove the tube from the flame, and gently pull the two ends apart, thus drawing out the tube where it has been heated (Fig. 5). Turn it continually while drawing it out.

Cut the tube at the middle of the contracted portion.

In sealing the end of a tube draw it out as above described, but draw the two ends apart. Then heat the tip of one of the ends in the flame, touch it with a piece of

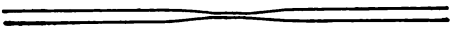

FIG. 5.

FIG. 6.

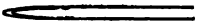

FIG. 7.

hot glass tubing, or hot glass rod, and draw off the particles of the glass until the end on being fused together will not show a knob of glass at its extremity. See Figs. 5, 6, and 7.

6. To bore a Hole through a Cork. — This is best done with a cork borer, an instrument consisting of a number of brass tubes sharp at one end and of different diameters.

First soften the cork by rolling it backward and forward upon the floor under the shoe. Choose a tube of the cork borer that is slightly smaller than the glass tube which is to be inserted in the hole in the cork. Place the cork end upward on the desk, and bore the hole with the cork borer, being careful to keep the tube of the cork borer perpendicular to the face of the cork. Do not bore the hole completely through the cork from above, but stop when a slight projection caused by the cork borer can be

seen on the under side of the cork. Then draw out the tube and bore in from the other side.

When made in this way the opening will be clean and have sharp edges.

If a cork borer is not at hand, a hole may be made by using a small round file.

7. To connect Apparatus. — In slipping a rubber tube over the end of a glass tube or in inserting a glass tube through the opening of a rubber stopper, always have the rubber wet. In inserting either a cork or a rubber stopper into a flask, grasp the flask at the end of the neck where the stopper is to be inserted. If the flask be held by the bottom, the insertion of the stopper may break the thin glass and badly lacerate the hand.

Experiment 1 (1)

a. Rub together in a mortar about 10 g. of iron filings and half that weight of sulphur.

Pass a magnet through the mixture.

Has a chemical change taken place?

b. Place some of the mixture in a test tube and heat it to redness in the flame of the Bunsen burner. If the

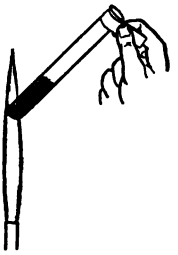

FIG. 8.

tube becomes too hot to hold, wrap a strip of cloth or a folded strip of paper around the upper end and take hold of the two ends of the strip (Fig. 8).

Note what occurs when the mixture is heated.

Allow the tube to cool, then remove the substance and grind it in a mortar.

Note its appearance.

Pass a magnet through it.

Has a chemical change taken place?

Give reasons for your answer.

Experiment 2

a. Place a little common salt in a test tube, add water, and warm in the flame until the salt is dissolved.

Taste the solution.

b. Pour the solution into a small porcelain evaporating dish and heat gently on the wire gauze over the flame

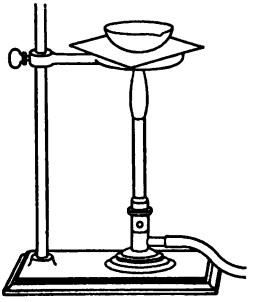

FIG. 9.

(Fig. 9) until the water is driven off and a solid substance remains.

What is its appearance?

Does it resemble the salt first used?

Taste it.

Has the salt been changed by this treatment?

Experiment 3

a. Place a piece of zinc in a test tube and pour upon it a few cubic centimeters of dilute sulphuric acid.

Note carefully what takes place.

b. When the zinc has entirely disappeared, place the solution in an evaporating dish and evaporate to dryness.

Does the solid which now remains resemble the zinc that was used?

How does it differ from the zinc?

Is this a chemical change?

Experiment 4

a. Heat a piece of iron wire in the Bunsen flame and examine it after it has cooled.

Has it undergone a physical or chemical change?

b. Introduce a piece of magnesium ribbon into the Bunsen flame, holding the ribbon with the crucible tongs. As soon as the magnesium begins to burn, bring the ribbon quickly over a piece of paper.

What kind of a change has the magnesium undergone?

What caused the change?

Has a new substance been formed?

Experiment 5 [illegible]

a Heat in a dry test tube about 1 g. of red mercuric oxide, holding the tube in the flame.

Does it change in color?

What appears on the sides of the tube?

b Heat a burning splinter of wood or match in the mouth of the tube.

What takes place?

What does this indicate concerning the effect of heat upon the mercuric oxide?

Has the red oxide of mercury been changed physically or chemically?

What caused the change?

Experiment 6 (3)

Rub together in a mortar small quantities of potassium iodide and lead nitrate.

What was the color of each of the substances before they were rubbed together?

What is the color of the mixture after rubbing?

What does this change indicate?

What caused the change?

Experiment 5 (2)

a. Place in a dry test tube about 10 g. of red mercuric oxide and heat it carefully over the flame.

Does it change in color?
What appears on the sides of the tube?

b. Hold a burning splinter of wood or match in the mouth of the tube.

What takes place?
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Experiment 7 (4)

a. Fill a small pan of agate ware or tin[1] with water. Fill a test tube with water, place the thumb over the end of the tube, and invert the tube in the pan of water. The tube should be completely filled with water.

b. Take a piece of metallic sodium as large as a small pea, wrap it in a small piece of filter paper, grasp it with the crucible tongs, dip the paper into kerosene, and bring it under the mouth of the inverted test tube (Fig. 10).

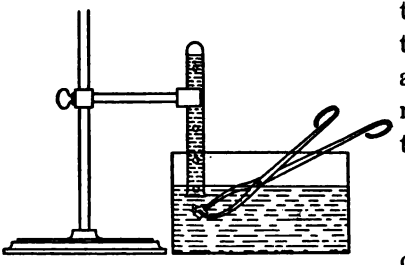

FIG. 10.

What occurs?

c. When the action of the sodium upon the water has ceased, close the mouth of the test tube with the thumb, remove it from the water, and then turn it upright. Bring it near a Bunsen flame and, removing the thumb, quickly thrust the mouth of the tube close to the flame.

How does the gas in the tube behave?

[1] It will be found convenient to have made by a tinner a pan of the shape and dimensions in centimeters shown in Fig. 11. The shelf A has in the middle a round hole 2½ cm. in diameter. Bottles or cylinders are placed mouth downward on this shelf over the hole when collecting gases over water. To prevent rusting, it is well to have the pan japanned.

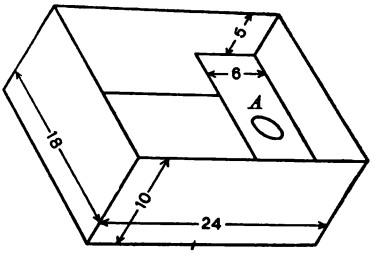

FIG. 11.

Experiment 8 (5, 6, and 7)

a. Place 20 g. of granulated zinc in a 250 cc. flask or bottle provided with a two-hole stopper, a funnel tube, and a delivery tube (Fig. 12). Add through the funnel tube 50 cc. of dilute sulphuric acid, 1 volume of strong acid diluted with 4 volumes of water. (In diluting strong

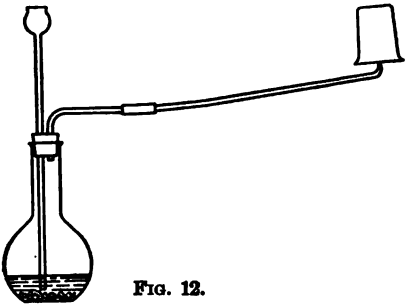

FIG. 12.

sulphuric acid, always pour the sulphuric acid into the water. Never pour the water into the acid, for the heat that is generated at the point where the small amount of water comes in contact with the acid is sufficient to cause the liquid to spatter with considerable violence.)

b. Allow the action to continue until all of the air that was in the bottle has been displaced. A mixture of hydrogen and air is very explosive, and if the gas escaping from the delivery tube is lighted before all of the air has been driven out of the bottle, a violent explosion will result. The gas issuing from the delivery tube should always be lighted in the following manner: invert over the end of the tube an empty test tube, allow this to fill with the gas, close the test tube with the thumb, and light the gas which it contains at the flame of a burner which is at least two

feet away from the delivery tube. Then immediately attempt to light the gas coming from the delivery tube with the flame issuing from the test tube. To do this, slip the test tube over the end of the delivery tube. If the gas in the generator is explosive, it will explode in the test tube and leave no flame. When, however, the flame in the tube lasts long enough to enable one to light the jet with it, it is evident that the gas in the generator is no longer explosive.

c. Place over the flame a dry bottle or beaker (Fig. 12).

What is the deposit that forms on the sides of the beaker?

d. Blow out the flame, allow the end of the delivery tube to cool, and then collect the escaping gas in bottles

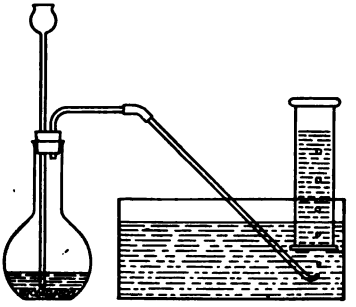

FIG. 13.

over water (Fig. 13). Introduce a burning splinter of wood into one of the bottles held mouth downward.

Does the wood burn in the gas?

Does the gas burn?

e. Hold a dry beaker over a candle flame, the flame of an alcohol lamp, and the flame of a kerosene lamp.

Is hydrogen present in these different substances?

Experiment 9 (9)

a. Take another bottle full of the hydrogen gas and pour the gas into a second bottle containing air. To do this hold both bottles mouth downward and pour the gas upward (Fig. 14).

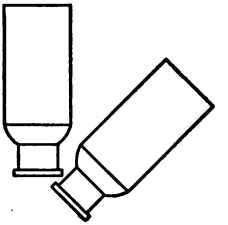

Fig. 14.

Hold the second bottle to the flame to ascertain whether hydrogen has passed into it.

How is this shown?

b. Attach to the delivery tube a piece of rubber tubing into the other end of which has been inserted a clay pipe. Blow a soap bubble with the gas and shake off the bubble from the pipe.

Does the bubble rise or fall?

Is the gas heavier or lighter than air?

Experiment 10 (10)

a. Mix together in a mortar or on a piece of paper 10 g. of potassium chlorate and an equal weight of manganese dioxide.[1] Transfer this mixture to a dry 100 cc. flask pro-

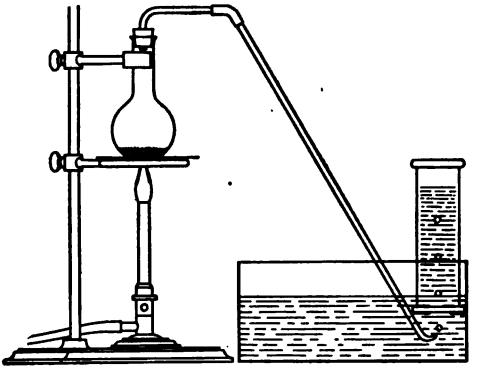

FIG. 15.

vided with a glass delivery tube as shown in Fig. 15. Heat the flask carefully, and collect the evolved gas in cylinders or bottles over water.

Note the color of the gas.

b. Blow a soap bubble with the escaping gas in the manner described under Experiment 9.

Does the bubble rise or fall?

[1] Manganese dioxide sometimes contains organic matter. This latter will cause an explosion when the mixture of the manganese dioxide and potassium chlorate is heated. The teacher, therefore, should always heat a small portion of the mixture to assure himself that it is not explosive, before permitting the class to perform this experiment in the laboratory.

Experiment 11 (11, 12, 13, 14, 15)

a. Slip a piece of window glass over the mouth of one of the jars of oxygen, remove the jar from the water and stand it upright. Insert a glowing splinter of wood in the gas.

What happens?

Does the gas take fire?

b. Repeat the experiment with a piece of charcoal which has been ignited in the Bunsen flame.

FIG. 16.

c. Place a small piece of sulphur in a deflagrating spoon and kindle it in the Bunsen flame. Lower the burning sulphur into a jar of oxygen (Fig. 16).

Do the substances burn with greater energy in air or in oxygen? Why?

d. Repeat this last experiment, using a small piece of phosphorus in place of the sulphur. (Phosphorus should *never* be touched with the fingers. Always pick it up with pincers or crucible tongs and cut it *under water*. Be sure that it is always completely covered with water in the bottle or jar in which it is kept.)

What occurs?

Is a new substance formed? Give reasons.

e. Take a piece of wire, such as is used for hanging pictures, heat the end of it, and dip it into a little powdered sulphur. Ignite the sulphur, and lower the wire into a bottle of oxygen. The bottle should contain a little water.

What happens to the iron wire?

What is the substance that is formed?

Does it resemble iron rust?

Experiment 12 (16)

a. Cover the bottom of a bottle one quarter of an inch deep with water, and place in it a piece of freshly scraped phosphorus. The piece should be large enough to project above the surface of the water.

Cover the bottle with a glass plate, and after a time slide the plate to one side and smell of the gas.

b. Introduce into the gas a piece of moistened potassium iodide starch paper.[1]

Does the paper show that ozone is present?

[1] Potassium iodide starch paper is prepared by dipping sheets of filter paper into a starch solution and drying them, and then dipping them into a one per cent solution of potassium iodide and drying them again. The paper is then cut up into narrow strips and preserved in glass-stoppered bottles. When a strip of the moistened paper is acted upon by ozone, the paper turns blue.

The starch solution is prepared by rubbing one part of starch with a little cold water and pouring this into one hundred parts of boiling water with constant stirring. The liquid is then poured into a tall beaker or cylinder, allowed to settle, and the clear portion is drawn off with a siphon.

Experiment 13 (17)

Attach a clay pipe by means of a piece of rubber tubing to a gas holder containing hydrogen, or to a gas pipe furnishing illuminating gas. Blow a soap bubble with the gas, and then, without detaching the bubble, connect the tube with a gas holder containing oxygen[1] and continue blowing the bubble until it is half again larger. Snap the bubble from the pipe, and as it rises touch it with a torch or lighted candle.

What happens?

What has been formed?

[1] *Never mix the hydrogen and oxygen before blowing the bubble, for the mixture is so violently explosive that serious accident might result.*

Experiment 14 (18)

a. Fill a beaker with water, add 3 or 4 cc. of sulphuric acid, then fill two test tubes with this liquid and invert the tubes in the beaker. Connect to the negative[1] pole of a galvanic battery an insulated copper wire. Remove the insulation on the last centimeter of the wire, and bend this upward in the form of a hook. Bring this under the open end of one of the test tubes. Connect the positive[2] pole of the battery with another such insulated wire. Remove the insulation for 2 or 3 mm. from the end, and wrap around this bare

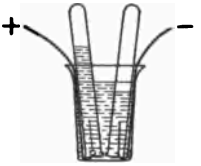

FIG. 17.

copper wire a piece of platinum wire long enough to project for about 2 cm. beyond the end of the copper wire. Melt some paraffin in a small evaporating dish, and cover the bare copper wire with a thick layer of this substance. Bend the end of the wire in the form of a hook, and bring this under the other test tube (Fig. 17). The water will be decomposed by the current, and gas will rise in each tube.

Does the same amount of gas rise in each tube?
If not, what is the proportion between the two gas volumes?

[1] The zinc plate or rod.

[2] The carbon plate.

b. Remove the wires, place the thumb over the tube containing the larger amount of gas, remove the tube from the liquid, and introduce into the tube a lighted match.

Does the gas resemble any gas with which you are already acquainted?

What is it?

Plunge a glowing splinter of wood into the gas in the other tube.

What is this gas?

If the two gases were allowed to rise in one tube and mix, and a flame was then applied to the mixture, what would happen?

What would be formed?

Experiment 15 (19)

Use the hydrogen generator already employed in Experiment 8. Connect the delivery tube with a wash bottle containing a little concentrated sulphuric acid to dry the hydrogen which bubbles through it.

Fill with dry, granular copper oxide a piece of hard glass tubing about 10 mm. in diameter and 30 cm. long.

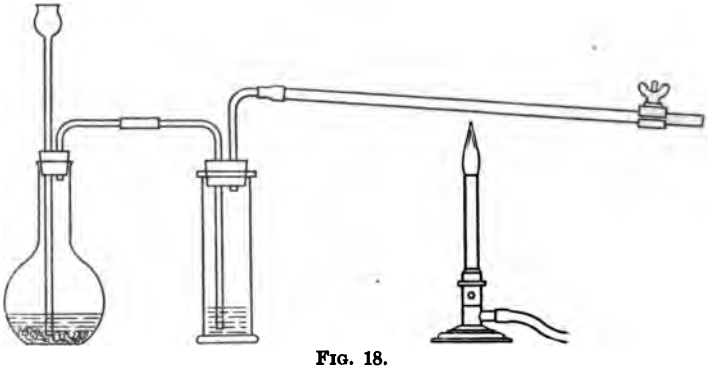

FIG. 18.

Connect one end of the tube with the exit tube of the wash bottle (Fig. 18). Start the generation of hydrogen, and when all of the air has been expelled from the apparatus (how can this be ascertained?), heat the copper oxide nearly to redness.

A new substance is formed.

Of what substances is it composed?
Which of these substances comes from the copper oxide, and which from the generator?
What is the change in the copper oxide?

Lay aside the tube and the substance which it contains for further use in Experiment 20.

Experiment 16

a. Prepare a filter by folding a disk of filter paper twice so that it forms a quadrant (Fig. 19); open this so that three layers of the paper are on one side and one

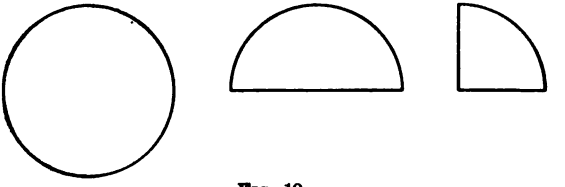

Fig. 19.

upon the other, and place it in a glass funnel. Press it against the sides of the funnel and moisten it with water. The paper should not reach the top of the funnel (Fig. 20).

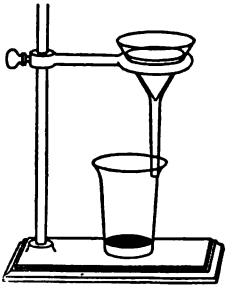

Fig. 20.

b. Powder a piece of marble, place it in a beaker, and fill the beaker half full of water. Heat the water.

Does the marble dissolve and disappear?

Pour the liquid upon the filter paper.

Is the liquid which passes through the paper clear?

c. Evaporate to dryness some of this liquid, which is termed the filtrate, by placing it in a porcelain evaporator and heating it over a flame.

Does any solid substance remain after the water has been driven off?

Has any of the marble been dissolved?

Experiment 17

a. Place some crystals of copper sulphate in a beaker half full of distilled water and heat over the flame.

Does the copper sulphate dissolve?

Filter some of the liquid through a filter paper.

Does the copper sulphate remain on the paper?
Is the filtrate colored?

Evaporate some of the filtrate to dryness.

Does a solid substance remain?
What is it?

b. Place the remainder of the copper sulphate solution in a flask fitted with a cork carrying a delivery tube.

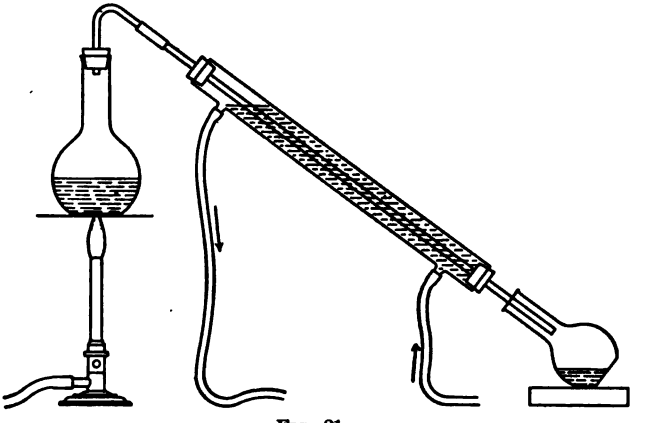

FIG. 21.

Connect the delivery tube with a condenser (Fig. 21). Place a receiving flask over the other end of the condenser. Start water flowing through the condenser and then heat the copper sulphate solution in the flask to

boiling. Continue the boiling until about half of the liquid has distilled over into the other flask. This liquid is termed the distillate. Place some of this distillate in an evaporating dish and evaporate to dryness.

Does a solid substance remain?

Has the copper sulphate been separated from the water by this procedure?

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Experiment 18

a. Place a few small crystals of alum in a test tube and heat carefully in the flame.

What is given off?

What change is there in the appearance of the alum?

b. Pulverize some copper sulphate and heat this powder in a test tube.

What change is there in the appearance of the substance?

To what is this change due?

Allow the tube to cool and add a few drops of water to the substance.

Does it change in color?

c. Place a few pieces of calcium chloride on a watch glass and leave it exposed to the air for a day or two.

What occurs?

What is the source of the moisture that you see?

What is this property termed?

d. Allow a few clear crystals of sodium sulphate to be exposed to the air for a few hours.

Have the crystals changed in appearance? Why?

What is this change called?

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Does a solid substance remain?

Has the copper sulphate been separated from the water by this procedure?

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Allow the tube to cool and add a few drops of water to the substance.

Does it change in color?

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What occurs?

What is the source of the moisture that you see?

What is this property termed?

d. Allow a few clear crystals of sodium sulphate to be exposed to the air for a few hours.

Have the crystals changed in appearance? Why?

What is this change called?

Experiment 19 (20)

a. Dry a small piece of phosphorus by pressing it with filter paper. Place it in a porcelain crucible, and float this in a deep pan half full of water. Place over the crucible a bell jar open at the top (Fig. 22). Mark the height at which the water stands in the bell jar. Ignite the phosphorus with a hot wire, and immediately insert a tight fitting stopper in the top of the bell jar. Observe carefully what happens during combustion.

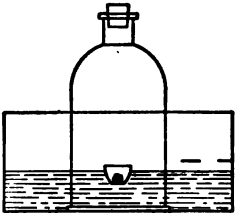

FIG. 22.

b. After combustion has ceased, allow the apparatus to stand until the fumes in the bell jar have disappeared. Now pour water into the pan until it stands at the same height as the water in the bell jar. Mark the height at which the water now stands in the bell jar.

Is there as much gas in the bell jar as there was at the beginning?

c. Remove the stopper and insert a burning match or splinter.

What happens?

What has become of the oxygen?

d. The volume of air which was first in the bell jar and the volume of gas which remains after combustion may be determined by holding the empty bell jar mouth upward and pouring in measured quantities of water until the two marks on the jar are reached.

What is the per cent of oxygen in the air as determined in this manner?

Experiment 20

Use the same apparatus as that already employed in Experiment 15, except that no zinc is to be placed in the flask and the hard-glass tube is now filled, not with copper oxide, but with the metallic copper formed in Experiment 15. Connect the exit end of the hard glass tube with a delivery tube which dips into a pan of water.

Now heat the hard glass tube in the Bunsen flame and pour water very slowly into the flask through the safety tube. This will drive air through the sulphuric acid and the dry air will then pass over the hot metallic copper. After about half of the air in the flask has been driven out, invert a cylinder or bottle over the end of the delivery tube, and then slowly drive over the rest of the air in the flask.

What change takes place in the appearance of the copper?

With what has the copper united?

What is formed?

What is the gas which passes over and collects in the bottle over water?

Experiment 21 (21)

Invert an empty graduated test tube over a dish filled with water. Clean a small piece of phosphorus by scraping it under water, push through it the end of a bent iron wire, and pass the phosphorus up into the tube (Fig. 23).

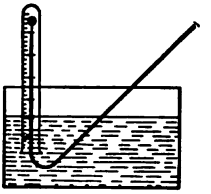

FIG. 23.

Allow the tube to stand for several hours, noting the height at which the water stands in the test tube, both at the beginning and after the action has ceased.

What portion of the air has disappeared?

What remains in the tube?

Experiment 22 (22)

a. Place in a mortar a few crystals of ammonium chloride and about the same amount of slaked lime and add a few drops of water. Rub the mixture with the pestle and note the odor of the gas which is set free.

What is it?

b. Dip a stirring rod in concentrated hydrochloric acid and hold the moistened rod over the mortar.

What results?

Experiment 23 (23)

a. Place about 20 g. of dry ammonium chloride in a 250 cc. flask, add the same weight of slaked lime, shake the flask to mix the substances, and then add enough water to form a thin paste. Insert in the neck of the flask a one-hole stopper carrying a short tube bent at a right angle. To this connect, by a piece of rubber tubing, a longer tube also bent at a right angle. Turn the longer delivery tube upward, heat the flask with a low flame, and lower over the delivery tube a dry bottle (Fig. 24).

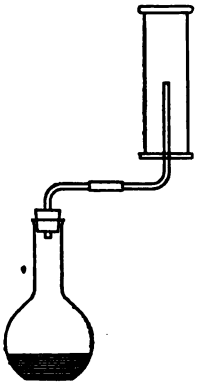

FIG. 24.

Does ammonia collect in the bottle?

Is it lighter or heavier than air?

b. Light a splinter and introduce it upward into the bottle.

Does the splinter continue to burn?

Does the ammonia burn?

c. Lower another bottle containing ammonia gas into a pan of water. Shake the bottle from side to side, keeping its mouth always below the surface of the water.

What occurs?

What does this show?

Experiment 24

a. Turn the long delivery tube (Fig. 24) downward and introduce it into a bottle containing about 10 cc. of water. The delivery tube should not dip into the water, but should reach to within a few millimeters of its surface. Again heat the flask carefully for a few minutes, then remove the flame and pour the water in the bottle into an evaporating dish.

Note the odor of the water.

b. Add dilute hydrochloric acid to the liquid in the dish until it no longer has an odor, and evaporate carefully to dryness, being sure that the dish is not heated after the water has been driven off.

Compare the substance which remains with the ammonium chloride which was first used.

Heat a little of each of the two substances in a dry evaporating dish.

What happens?

Experiment 25 (24)

Place in a tubulated[1] retort about 10 g. of sodium nitrate. Arrange the apparatus as shown in Fig. 25, supporting the retort on the wire gauze and inserting the neck in a clamp. Introduce the end of the retort into a dry test tube which stands in a beaker of cold water. Pour upon the sodium nitrate about 20 cc. of strong sulphuric acid. Use a glass funnel in doing this, and be sure that no sulphuric acid enters the neck of the retort. Insert the stopper in the neck of the retort. Heat the retort gently.

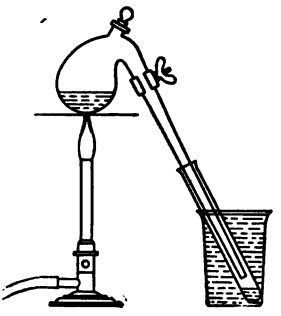

FIG. 25.

What remains in the retort at the end of the experiment?

What distils over into the test tube? What is its color?

Why is it not colorless?

[1] A tubulated retort is one that has a short neck or tubulus which is usually closed by a glass stopper.

Experiment 26 (26, 27)

a. Heat a small piece of copper with some of the nitric acid that has just been made, first diluting the acid with an equal volume of water.

Is a gas given off?
What is its color?
Into what is the copper changed?

b. Do the same with a small piece of lead, diluting a portion of the acid with three volumes of water. Warm the liquid. After the lead has dissolved evaporate the solution to small bulk and let it stand.

What is the substance which appears in the form of crystals?

c. Pour another portion of the diluted nitric acid (1:1)[1] upon a few clippings of quill or bits of white feather.

What change takes place in the color of the substance?

[1] This expression, (1:1), means one volume of acid and one volume of water.

Experiment 27 (28)

Place a small crystal of ferrous sulphate in a test tube, cover it with 3 or 4 cc. of water and shake until the crystal is dissolved. Do not heat the water. Now hold the tube in a slanting position and carefully pour down the side 4 cc. of strong sulphuric acid. This should be done in such a manner that the two liquids will remain in separate layers without mixing. Cool the liquid by holding the test tube under the hydrant. Drop into the tube a small crystal of any nitrate, such as sodium nitrate, and gently tap the tube with the finger.

What appears at the boundary between the two liquids?

Experiment 28 (29)

Add to a beaker of water a few drops of an acid, such as nitric or sulphuric acid. To another beaker of water add a few drops of ammonia. Dip into the first beaker a piece of blue litmus paper.

What change in the color of the paper occurs?

Now dip the same paper or a fresh piece of red litmus paper into the beaker containing ammonia. Note the change of color.

Experiment 29 (30)

a. Place 5 cc. of water in a small evaporating dish and dip into the water pieces of red and blue litmus paper. Neither should change in color. Drop into the water a small piece of metallic sodium. After the action has ceased, dip the two pieces of litmus paper into the liquid.

Is it acid or alkaline?

Is the substance formed an acid, a base, or a salt?

b. Carefully add dilute hydrochloric acid to the liquid until neither blue nor red litmus paper changes in color when dipped into it.

What does the solution now contain?

Evaporate the solution to dryness.

What is the substance which remains?

Is it an acid, a base, or a salt?

Experiment 30 (31)

a. Place about 15 g. of ammonium nitrate in a flask, and connect the flask by means of a one-hole stopper and delivery tube with the wash bottle used in Experiment 15, the wash bottle now being empty and dry. The delivery tube from the flask should end just below the stopper of the bottle. Connect the exit tube of the wash bottle with a delivery tube. Heat the ammonium nitrate in the flask carefully on the wire gauze, and after the reaction has proceeded for a few minutes, collect the escaping gas in bottles over water.

What is formed in this reaction in addition to a gas?

b. Insert a glowing splinter into one of the bottles of gas.

Does it continue to burn? Why?

Place a bit of phosphorus in a deflagrating spoon, set it on fire, and lower it into another bottle of the gas.

Note the result.

Experiment 31 (32)

a. Place 15 g. of copper or copper turnings in a flask provided with a funnel tube and a delivery tube, allowing the delivery tube to dip under water in a pan. Pour through the funnel tube 20 cc. dilute nitric acid (1:1). Then add strong nitric acid, a little at a time, until there is a brisk evolution of gas. If the action in the flask becomes too violent, pour in some cold water through the funnel tube. After the brownish vapors have disappeared from the flask, bring over the end of the delivery tube inverted bottles *completely* filled with water.

What is the color of the gas which collects in the bottles?

b. Lift one of the bottles from the water so as to admit air.

What takes place?
What is formed?

c. Remove the other bottle of gas from the water, and lower into it a burning splinter.

Does the gas support combustion?

Experiment 32 (33)

Place 10 g. of zinc dust in a flask, and add a solution of potassium hydroxide, made by dissolving 5 g. of the substance in 100 cc. of water. Warm the mixture, and when gas comes off freely, add from 5 to 10 drops of dilute nitric acid (1 : 1). The solution in the flask must remain alkaline throughout the entire experiment.

Note the odor of the gas which is given off.

What does the odor indicate the gas to be?

Confirm this by testing for ammonia in two other ways.

Experiment 33 (35)

Place 100 cc. of water in a flask, and add to it about 8 cc. of thick brown molasses. Heat the liquid to boiling, and then pour off into a beaker about 10 cc. of it. To the remainder of the liquid in the flask add 20 g. of animal charcoal, and boil the liquid gently for 3 or 4 minutes. Filter the solution. Compare the color of the filtrate with that of the original solution.

Is it lighter than before the addition of the charcoal? To what is the change in color due?

Experiment 34 (35)

Add to 100 cc. of water 5 cc. of a dark-colored clear litmus solution and 10 g. of animal charcoal. Boil for a few minutes and filter.

Has the litmus solution been decolorized?

Experiment 35 (36)

Grind together in a mortar 5 g. of crystallized sodium acetate, 10 g. of sodium hydroxide, and 20 g. of powdered quicklime. Heat the mixture gently in an iron pan until it is perfectly dry. Then transfer it to a piece of hard-glass tubing which has been fused together at one end. Place the tube in a clamp, fasten it in a horizontal position, and tap it until there is left above the powder a

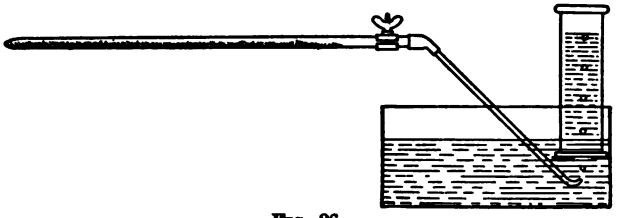

FIG. 26.

free channel for the escaping gas (Fig. 26). Connect the open end of the hard-glass tube with a delivery tube dipping under water. Heat the mixture carefully, beginning the heating near the closed end. After the air in the apparatus has been driven out, collect the escaping gas in bottles over water. When the evolution of gas ceases, detach the delivery tube, and then remove the burner.

Test the gas to see whether it either burns or supports combustion.

What is the gas?

Experiment 36

Fit a bottle with a single-hole stopper carrying a piece of straight glass tubing about 5 cm. long and ending flush with the lower side of the stopper (Fig. 27). Fill the bottle to within about 3 cm. of the top with water, drop

FIG. 27.

into it a piece of calcium carbide[1] about as large as a hazel nut, insert the stopper, wait a few moments until the air in the top of the bottle has been displaced, and then light the gas issuing from the glass tubing.

What is the gas?

What is the character of the flame?

Hold an evaporating dish just above the flame.

What collects on the dish?

What is the substance floating about in the water after the reaction is ended?

[1] Calcium carbide is very generally used for bicycle lamps, and can be obtained from almost any dealer in bicycle supplies.

Experiment 37 (37)

a. Seal one end of a piece of hard-glass tubing, fill the tube with small pieces of soft coal,[1] and connect it by means of a piece of rubber tubing with a wash bottle half full of water (Fig. 28). Allow the exit tube of the wash bottle to dip under water in the pan.

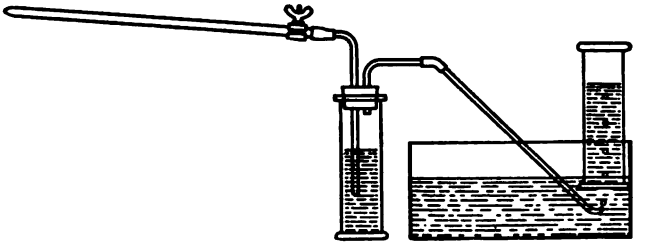

FIG. 28.

Heat the hard-glass tube with the Bunsen flame, and after the operation has continued for a minute or two, collect the escaping gas over water. When no more gas escapes, discontinue the heating and disconnect the apparatus at once.

Examine the gas in the bottle.

Will it burn, and if so, what is the color of the flame?

Of what does the gas consist?

[1] The teacher should secure for this experiment a sample of good gas coal, or, even better, a piece of cannel coal. The products formed by the destructive distillation of various kinds of bituminous coal vary greatly, and the student should therefore be especially careful in his observation of the details of the experiment and his examination of the products.

b. Note the odor of the water in the wash bottle.

Is the water acid or alkaline?
What does it contain?

c. Describe in detail any other products of the reaction, also the behavior of the coal during the heating.

What is the substance left in the hard-glass tube after the operation is ended? Ascertain this by cutting the tube and emptying out that portion of the charge which has been most highly heated.

Experiment 38

Introduce into the nonluminous portion of a fish-tail gas flame a glass tube in the manner shown in Fig. 29. Light the gas issuing from the tube.

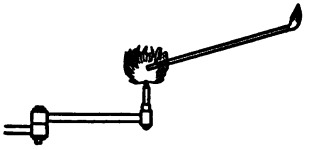

FIG. 29.

What does it teach us concerning the conditions existing in this portion of the gas flame?

Experiment 39 (38, 39)

a. Pour a little clear limewater into a clean test tube. Then pour out the liquid, and invert this test tube, which still has a film of limewater adhering to the glass, over a candle flame or a low Bunsen burner flame.

What forms in the test tube?
To what is it due?
What element is thus proven to be present in the candle or the illuminating gas?

b. Pour 2 or 3 cc. of clear limewater into a test tube, and with a piece of glass tubing, blow air from the lungs through the liquid. Note what changes are seen and explain them.

Experiment 40 (40)

Dissolve about 15 g. of grape sugar in 200 cc. of water. Place the solution in a flask and add half a cake of yeast. Insert in the neck of the flask a stopper with a delivery tube. Connect the delivery tube with a wash bottle con-

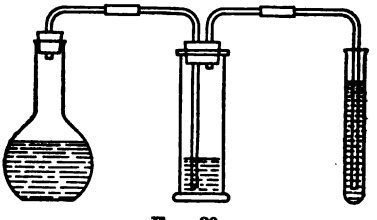

FIG. 30.

taining clear limewater (Fig. 30). The exit tube of the wash bottle should dip into another solution of limewater. (Why?) Place the whole apparatus in a warm place and allow it to stand over night.

Has carbon dioxide been formed?

What proof have you?

Experiment 41 (41, 42, 43)

a. Place in a flask some pieces of chalk, limestone or marble, insert a stopper carrying a funnel tube and a delivery tube, and add through the funnel tube dilute hydrochloric acid, a little at a time. Pass the escaping gas into limewater.

What is the gas?

b. Remove the limewater and collect two or three bottles of the gas over water in the usual way. Lower a lighted splinter into one of the bottles of gas.

What results?

c. Pour one bottleful of the gas very slowly into a bottle of the same size containing air. Ascertain, by lowering into it a lighted splinter, whether the gas has passed to the second bottle.

Is the gas heavier or lighter than air?

Experiment 42 (45)

Melt some paraffin in an evaporating dish and with a small brush or bit of rag spread the paraffin upon the surface of a piece of window glass. Scratch a design through the wax with the point of a pin.

Place in a small lead dish some powdered fluorspar and add strong sulphuric acid sufficient to form a paste.

Place the prepared glass over this dish, paraffin downward, and leave it there over night. Then remove the paraffin and note whether the glass has been etched.

What is it that has caused this?

Experiment 43 (46)

a. Use the apparatus shown in Fig. 31, placing in the flask a mixture consisting of 10 g. of finely powdered manganese dioxide and 10 g. of common salt. Place 10 cc. of water in a beaker and slowly pour into this an equal volume of strong sulphuric acid. Cool the liquid. Introduce this dilute acid through the funnel tube and warm the flask gently on the wire gauze. Collect the gas in dry bottles by displacement of air in the manner shown in the Fig. 31, introducing the glass tube into the bottle through the opening in a paper or cardboard disk. When a bottle is full of the gas, carefully remove it and cover it at once with a glass plate.

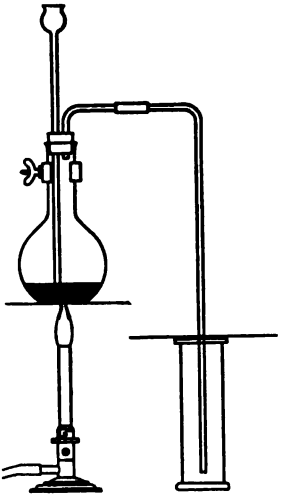

FIG. 31.

What is the color of the gas?

b. Ascertain its odor by placing the palm of the hand for a moment over one of the bottles and then bringing the hand to the nostrils. *Avoid inhaling larger amounts of the gas.*

Experiment 44 (49)

a. Place some pieces of dry colored calico in one of the jars of chlorine gas prepared in the preceding experiment, and in another place some pieces of moist calico.

What is the action in each case? Why?

b. Place some moist pieces of red and blue litmus paper in a jar of chlorine.

What change of color results?

c. Make some marks with ordinary ink on a piece of printed newspaper, moisten the paper, and place it in a jar of chlorine.

What is the action on the two kinds of ink?

Experiment 45 (48)

a. Pour some powdered antimony into a jar of chlorine gas. Describe and explain the result.

b. Place a small piece of metallic sodium in a deflagrating spoon. Heat it in the Bunsen flame until it takes fire, and then lower it into a jar of chlorine.

What occurs?

What are the white fumes that are seen?

c. Compare this method of forming the compound with that employed in Experiment 29. (The brown fumes which appear in this experiment are caused by the union of the iron of the spoon with the chlorine.)

Experiment 46 (47)

Pass the gas from the generator (Experiment 43) into a flask of water.

Does the gas dissolve in the water?

Fill a test-tube with this solution, and pour the remainder into a small beaker. Invert the tube in the solution. Place it in the sunlight and allow to stand for some time.

What is the gas that is set free?

Prove the correctness of your statement by testing the gas, and describe the tests which you make.

Set aside a bottle of the chlorine gas for the following experiment.

Experiment 47 (50)

a. Prepare hydrogen as described in Experiment 8, but bend the delivery tube as shown in Fig. 32. Light the

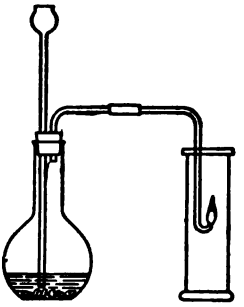

FIG. 32.

escaping jet of hydrogen in the usual manner (see Experiment 8), and lower the burning jet into a jar of chlorine.

Does the hydrogen continue to burn?

Is there a change in the color of the gas in the bottle?

b. Lower pieces of moist red and blue litmus paper into the gas in the bottle.

What is the result?

What is formed in the reaction?

Experiment 48 (51)

a. Use the apparatus described in Experiment 43. Place in the flask about 20 g. of sodium chloride (common salt). Add to 10 cc. of water in a beaker 30 g. (about 17 cc.) of concentrated sulphuric acid. Pour this diluted acid through the funnel tube, and gently heat the flask until there is a fairly rapid evolution of gas.

b. Fill some dry bottles with the gas by displacement of air, covering each with a glass plate as soon as it is full. Invert one bottle of the gas in a pan of water.

Is the gas soluble in water?

c. Lower a lighted splinter into one bottle of the gas.

What is the result?

d. Dip a stirring rod into strong ammonia, and bring it to the mouth of one of the bottles.

What results, and what is formed?
In what previous experiment has use been made of this reaction?

e. Introduce the delivery tube into a bottle containing a few cubic centimeters of water. The delivery tube should not dip into the water. After the action has continued for some minutes, pour part of the water into a test tube.

What is its action on blue litmus paper?
Drop into the test tube a piece of zinc.
Is the zinc attacked?
What is the escaping gas?
From what does it come?
What else is formed in the test tube?

f. Pour the remainder of the solution in the bottle into a small flask containing 2 or 3 g. of manganese dioxide. Warm the flask.

What gas is given off?

From what does it come?

What elements have you thus proved by experiment to be present in the gas formed by the reaction of sulphuric acid upon salt?

Have you as yet any proof that the gas contains only two elements?

How could that point be determined?

Experiment 49 (54)

a. Place 20 g. of manganese dioxide in a flask provided with a funnel tube and a delivery tube. Connect the flask with a wash bottle containing water, and introduce the delivery tube from the wash bottle into a wide test tube or narrow bottle containing a solution of potassium hydroxide which has been made by dissolving 15 g. of potassium hydroxide in 15 cc. of water. Pour into the flask through the funnel tube 50 cc. of concentrated hydrochloric acid, and warm the flask very gently.

What is the reaction that takes place in the flask?

b. When the gas is no longer absorbed by the potassium hydroxide solution, remove the latter, and replace it by another test tube containing a dilute solution of potassium hydroxide, 3 g. of the substance dissolved in 15 cc. of water. Continue passing the chlorine through this weaker solution.

Experiment 50 (55)

a. Transfer the first potassium hydroxide solution obtained in Experiment 49 to a beaker, cool it by placing the beaker in cold water, and collect on a filter paper the crystals which separate. Spread out the filter paper containing the crystals upon other pieces of filter paper, and allow the crystals to dry.

What is this substance?

b. Evaporate the filtrate just obtained to small bulk and cool it. Collect and dry the crystals here obtained in the same manner as just described above.

c. Evaporate the filtrate from this second crop of crystals to dryness.

d. The process by which the first two portions of crystals are obtained is known as fractional crystallization. The substance that is more insoluble will separate out first, and that which is more soluble will remain in solution until more of the water has been removed. The intermediate crops of crystals will naturally contain both the more insoluble and the more soluble substances.

Is the substance which is obtained on evaporating the liquid to dryness the same as that which first separated as crystals when the liquid was cooled?

e. Place some of the first crop of crystals in a dry test tube, and add a few drops of strong sulphuric acid.

What gas is given off?

What would be formed by adding strong sulphuric acid to the substance obtained by evaporating the second filtrate to dryness if it were pure?

Perform the experiment and note the result.

Experiment 51

Pour into a beaker the dilute solution of potassium hydroxide through which the chlorine was passed in Experiment 49.

Add to it a few drops of dilute sulphuric acid.

What has formed in this solution?

What is given off?

Experiment 52 (53)

Place 10 g. of "chloride of lime" in a flask and add 40 cc. of water. Shake thoroughly and then filter.

With the clear filtrate repeat the bleaching experiments described in Experiment 44, first moistening the objects with very dilute sulphuric acid (2 drops of concentrated sulphuric acid to 50 cc. of water).

Experiment 53

a. Mix 2 g. of finely powdered potassium bromide with twice its weight of manganese dioxide. Place the mixture in a retort. Add about 40 cc. of dilute sulphuric acid (1:6 by volume). Slant the neck of the retort downward, allowing it to project into a test tube which stands in a beaker of water (see Fig. 25). Heat gently on the wire gauze.

What is the color of the gas seen in the retort?
What is the substance which distills over?
What is its odor?

b. Prepare a small amount of bromine water by pouring a portion of the distillate into about 5 cc. of water. Set this aside for use in Experiment 57.

c. Prepare a solution of potassium hydroxide by dissolving 5 g. of the substance in 5 cc. of water. Add to this the remainder of the distillate.

Does the color of the bromine still remain?
What is formed?

Experiment 54

Place a few crystals of potassium bromide in a test tube, add a cubic centimeter of strong sulphuric acid, and warm slightly.

What is given off?
Does the gas possess any color?
What is the difference between this action and the action of the sulphuric acid upon sodium *chloride?*

Experiment 55 (57)

Place a little iodine in a dry test tube and heat gently.

What is the color of the vapor?
Does it easily condense to a solid?
What is the process called when a solid is vaporized and again condensed?
Is the substance made purer by passing through this change? Why?

Experiment 56

Mix 2 g. of powdered potassium iodide with twice its weight of manganese dioxide. Place the mixture in a retort, add 40 cc. of dilute sulphuric acid (1:6 by volume), mix the mass thoroughly, and heat gently on the wire gauze.

What is given off?

Where does it collect?

Experiment 57 (58, 59, 60)

a. To small portions of iodine in test tubes add in one case a little water, in another alcohol, and in the third a solution of potassium iodide.

In which of these liquids is the iodine most easily soluble?

b. Make some starch solution by the method described under Experiment 12. To some of this solution add a drop of the solution of iodine in potassium iodide prepared above.

What is the effect of the addition?

c. To other portions of the starch solution add a little bromine water and a few drops of chlorine water.

Does either substance color the starch?

Is the color the same as with iodine?

d. Add a few drops of starch solution to the solution of potassium iodide.

Does any change take place?

Now add to this mixture a few drops of chlorine water.

What is the result?

What causes the change?

Experiment 58 (63)

a. Fill a test tube one-third full of sulphur and heat it gradually over the flame. Keep a complete record of all the changes through which it passes. Pour some of the hot sulphur into a beaker of cold water.

Is this sulphur brittle or elastic?

b. Place some powdered sulphur in a test tube, add 3 to 4 cc. of carbon disulphide,[1] and shake until the latter is saturated with sulphur. Pour the solution upon a watch glass and allow it to stand until the carbon disulphide has evaporated.

What is the appearance of the crystals which remain? Color? Form? Elastic or brittle?

Experiment 59 (62)

Place some sulphur in a small beaker or a crucible, heat it until it melts, allow it to cool, and just as a crust begins to form, quickly pour into water that portion which still remains liquid. Note carefully the properties of the crystals which remain in the dish.

[1] Carbon disulphide is very inflammable. *Never handle it in the neighborhood of a flame.*

Experiment 60

a. Melt some sulphur in a test tube and introduce into it while it is boiling a piece of copper wire and of iron wire.

What changes take place?

What has been formed in each case?

b. Mix 2 g. of finely powdered sulphur with about 4 g. of zinc dust. Place the mixture upon a brick or tile and ignite it.

What happens?

What is formed?

c. Mix 3 g. of powdered sulphur with an equal weight of fine iron filings and heat the mixture in a dry test tube.

What compound is formed?

Allow the tube to cool, break it, and drop some of the substance into dilute hydrochloric acid.

What gas is given off?

Experiment 61 (64)

a. Use the apparatus shown in Fig. 31. Place some pieces of ferrous sulphide (iron sulphide) in the flask and add through the funnel tube either dilute sulphuric or hydrochloric acid. Do not heat the flask. Collect a bottle full of the gas by displacement of air (see Fig. 31), and test it to see whether it supports combustion or is combustible.

What is formed when the gas burns in the bottle?

b. Turn the delivery tube upward and light the escaping gas.

What is formed by this combustion?
Are the products the same in both cases?

c. Turn the delivery tube downward again and pass the gas through a bottle of water. After the water has become well saturated with the gas, detach the generator and use the solution of the hydrogen sulphide in Experiment 62.

Experiment 62 (65)

Place in test tubes about 2 cc. each of solutions of copper sulphate, cadmium sulphate, tartar emetic, zinc sulphate, and ferric chloride. Add to each solution 3 to 4 cc. of the solution of the hydrogen sulphide and note the character and color of the precipitates which form. Repeat these experiments with the same solutions, but first adding to each solution about 1 cc. of dilute hydrochloric acid before the addition of the hydrogen sulphide.

Is the result the same in each case as before the addition of the hydrochloric acid?

Experiment 63

Mix 2 cc. of the copper sulphate solution with the same amount of a solution of zinc sulphate. Add 1 cc. of dilute hydrochloric acid. Warm the liquid and then pass through it hydrogen sulphide gas until the blue color of the solution disappears. Filter.

What remains on the paper?
What passes through into the filtrate?

Neutralize the free hydrochloric acid in the filtrate by adding dilute ammonia drop by drop.

What is the precipitate which forms?

Experiment 64 (67, 68)

a. Use the apparatus shown in Fig. 31. Place in the flask 20 g. of copper turnings or scraps of sheet copper, add through the funnel tube 40 cc. of strong sulphuric acid, and heat on the wire gauze. The flame should be low at first to avoid breaking the flask and should gradually be turned up until the acid has reached quite a high temperature. It then begins to act upon the copper, and a continuous evolution of gas results.

What is the gas?
What is its odor?
Does it burn or support combustion?

b. Pass the gas into a bottle of water, and with the solution test the bleaching character of sulphur dioxide, using the same substances that were employed in Experiment 44.

Experiment 65 (69) (Fig. 35)

a. The apparatus comprises two flasks, a small one for generating nitric oxide from copper and nitric acid (see Experiment 31), and the larger flask fitted for the preparation of sulphur dioxide (see Experiment 64). The delivery tubes from these flasks pass through the openings of a four-hole stopper which is inserted in a cylinder or

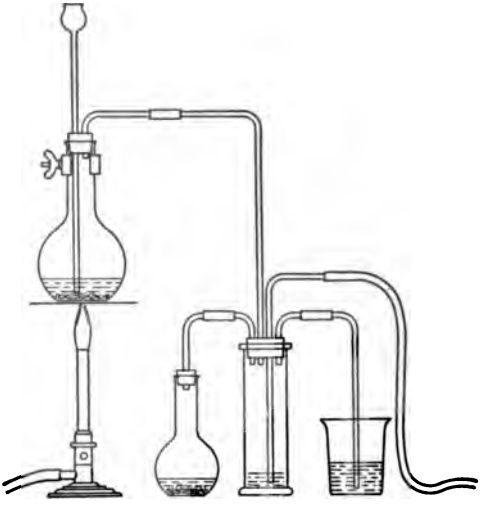

FIG. 33.

wide-mouth bottle. The tubes should end about 2 cm. below the stopper. The third opening in the stopper contains a piece of glass tubing reaching to the bottom of the bottle, through which air can be blown by means of a piece of rubber tubing attached to it. The bottle should contain about 10 cc. of water. The fourth tube from this bottle is an exit tube, the end of which dips below water in a beaker.

b. In performing the experiment, first pour dilute nitric acid upon the copper in the small flask, and add sufficient of the concentrated nitric acid to start a brisk evolution of gas. Insert the stopper in the flask, and then carefully heat the larger flask until a steady current of sulphur dioxide is evolved. The red color of the fumes in the bottle will disappear. Whenever this occurs, blow through the rubber tube until the color reappears. The sulphuric acid which forms will, of course, collect chiefly in the water at the bottom of the bottle.

What are the crystals which appear on the sides of the bottle?

c. Discontinue heating the sulphur dioxide generator, and when action has ceased, disconnect the bottle, and by carefully tilting it run the water up on the sides so that it comes in contact with the white crystals that have collected there.

Is a gas given off and do the crystals dissolve?

d. Now pour the liquid into an evaporating dish, and heat on the wire gauze to gentle boiling. Continue heating until the liquid has evaporated down to about one half its original volume.

Experiment 66

a. Hold a splinter of wood in the sulphuric acid prepared in the preceding experiment.

What is the action on the wood?

b. To 5 cc. of water in a test tube add about ten drops of the acid in the dish. Add a few drops of this diluted acid to a solution of barium chloride which has been acidulated with dilute hydrochloric acid.

What is the result?
What does it indicate?

c. Drop into the acid remaining in the test tube a piece of zinc.

What is the action which here takes place?

Experiment 67 (70)

Dissolve 2 or 3 g. of sugar in as little water as possible and add an equal volume of strong sulphuric acid. Shake gently to cause the liquids to mix, and at once place the test tube in a beaker in the sink.

What action takes place?
What is extracted from the sugar?
What remains behind?

Place a splinter of wood in strong sulphuric acid.

What results?

Experiment 68 (71)

Fill a test tube one-third full of strong sulphuric acid, and mark on the side of the test tube the height at which the acid stands. Leave it exposed to the action of the air for a day or two.

Has it increased or decreased in volume?
To what is the change due?

Experiment 69 (72)

Pour about 1 cc. of carbon disulphide into a test tube and drop into it a very small piece of phosphorus. When the phosphorus has dissolved pour the solution upon a piece of filter paper, first placing the paper on a tile or in an iron pan.

Why does the phosphorus take fire of itself when the carbon disulphide evaporates?
Will it do so when a piece of phosphorus is simply exposed to the air?

Experiment 70 (73)

Place some powdered boneblack upon a tile or brick, and put upon this a piece of phosphorus about as large as a pea. Heap the boneblack up around the phosphorus, but leave the top of the phosphorus exposed to the air.

Does the phosphorus now take fire? Why?

Experiment 71 (74)

a. Prepare hydrogen in the apparatus shown in Fig. 34, connecting with the short delivery tube from the flask a U tube containing dry, granular calcium chloride for absorbing any moisture in the gas. Join the U tube to a hard-glass tube about 20 cm. long, and drawn out and

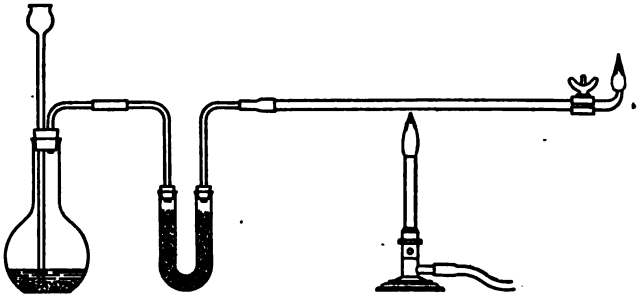

FIG. 34.

turned up at the farther end (Fig. 34). Light the hydrogen at the jet in the usual manner and then pour into the flask through the funnel tube a *few* drops of a solution of any compound of arsenic.[1] Be sure that the flame burns throughout the whole experiment, since the gas which comes from the generator is *very poisonous*.

Hold in the flame a piece of porcelain.

What is deposited upon it?

[1] A suitable solution of arsenic may be prepared by dissolving, with the aid of heat, 3 g. of arsenic trioxide in a mixture of 77 cc. of water and 10 cc. of concentrated hydrochloric acid.

Note carefully the appearance of the stain.

Does it resemble soot?

What is the compound of arsenic that is present in the escaping gas?

b. Heat the hard-glass tube near the middle with a low Bunsen flame.

What is deposited on the inner walls of the tube?

Can this deposit be driven along the tube by carefully heating it?

Experiment 72

Pass hydrogen sulphide gas into a solution of arsenic. Prepare the hydrogen sulphide in the manner described in Experiment 61.

What is the color of the precipitate that is formed?

What is it?

Experiment 73

Draw out and seal a glass tube (preferably hard glass) as shown in Fig. 35. When it is cold, drop into the tube powdered arsenic trioxide sufficient to fill the tip of the tube for about one-half a centimeter. Into the upper part of the tip bring a splinter of charcoal. Heat in a low Bunsen flame, first heating the charcoal and then, when this is hot, allowing the flame to strike the arsenic trioxide. If the charcoal is not hot enough, arsenic trioxide will volatilize above the charcoal, as a white sublimate.

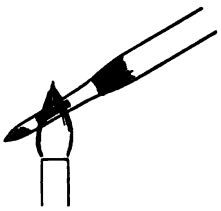

FIG. 35.

What collects on the walls of the tube above the charcoal?

What is its color?

What is the reaction which takes place between the vapor of the arsenic trioxide and the glowing charcoal?

Experiment 74 (75)

a. Dissolve some crystals of borax in the least possible quantity of boiling water, and add to the solution an equal volume of strong hydrochloric acid. Cool under the hydrant.

What is the substance that separates in crystals?

b. Fill the test tube with cold water, place the thumb over the tube, and shake it a few times. Allow the crystals to settle and carefully pour off the clear liquid above them.

What remains dissolved in the water and is thus removed?

c. Pour 3 or 4 cc. of 95 per cent alcohol upon the crystals in the test tube and warm gently.

Do the crystals dissolve?

d. Try to dissolve some powdered borax in alcohol.

What is the result?

e. Place some powdered borax in an evaporating dish, cover it with alcohol, and add three to four drops of concentrated sulphuric acid. Light the alcohol. Describe the appearance of the flame.

Experiment 75 (76)

Prepare a strong solution of sodium sulphate, add to it sufficient litmus solution to color it distinctly, and then

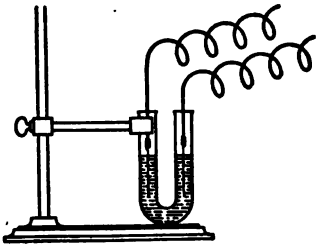

FIG. 36.

transfer it to a small U tube. Introduce into the two arms of the U tube platinum wires attached to the copper wires coming from a small galvanic battery (Fig. 36).

What changes of color take place when the current passes through the sodium sulphate solution?

What is set free at the negative pole and what at the positive?

What is the first action of the current upon the sodium sulphate?

Experiment 76 (77)

Throw into a vessel of cold water a piece of metallic potassium half as large as a pea. Describe fully what is seen, and explain the chemical action which takes place between the potassium and the water.

Do the same with a piece of sodium.

Is its action similar to that of potassium in all respects?

Experiment 77

a. Place 50 cc. of a solution of ammonium carbonate[1] in a flask, add 15 g. of pure pulverized sodium chloride, cork the flask, and shake it until no more of the salt will dissolve. There is thus obtained a strong solution of ammonium carbonate saturated with sodium chloride. Filter and place the clear filtrate in a small flask. Through this liquid pass carbon dioxide, made as in Experiment 41, *a*: wash the gas by passing it through a wash bottle containing water. When no more precipitate is formed, collect on a filter paper the crystals in the flask, press them between sheets of filter paper to remove most of the moisture, and then set the substance in a warm place to dry.

[1] This solution should be prepared in large quantity by the teacher. Dissolve, without the aid of heat, 600 g. of ammonium carbonate in 2100 cc. of water to which 600 cc. of strong ammonium hydroxide has been added.

Experiment 78

Does the compound obtained in Experiment 77 differ in chemical behavior from the ammonium carbonate and the sodium chloride which were used in the beginning?

To ascertain this, perform the following experiments:

Heat two or three crystals of ammonium carbonate in a dry evaporating dish.

Is there a residue?

Do the same with some of the substance which has been formed in the experiment.

What remains in the dish?

Place some of the powder in a test tube, and add dilute hydrochloric acid.

What gas is given off?

Dissolve another portion of the substance in water, and test its action upon litmus paper.

What is the substance?

Experiment 79

Place some common ammonium chloride in a small dry evaporating dish, cover the dish with a clean watch glass, and heat the dish very gently with a low Bunsen flame, holding the burner in the hand and moving the flame backward and forward under the dish.

Is the ammonium chloride that collects upon the watch glass purer than that in the dish?

What is this process of purification called?

Experiment 80 (78)

Add a few drops of a solution of ammonium sulphide to small amounts of the following solutions contained in test tubes: zinc sulphate, ferrous sulphate (iron sulphate), copper sulphate, manganese chloride, arsenic trioxide (see Experiment 71), and antimony trioxide, prepared in the same way as the arsenic solution.

Note the color of the precipitates, and then add to the contents of each test tube several cubic centimeters of ammonium sulphide.

Do any of the precipitates dissolve, and if so, which ones?

Experiment 81

Add to 2 or 3 cc. of a solution of an ammonium salt the same volume of a strong solution of potassium hydroxide or sodium hydroxide, and warm the liquid.

What is set free?

What is formed in the solution?

Experiment 82 (79)

a. Place some pieces of quicklime in a dish, and drop on just enough water to moisten the lime thoroughly. Allow it to stand for a few minutes. Describe what occurs.

What is formed?

b. Transfer the slaked lime to a flask. Fill the flask half full of water, cork, and shake. Filter.

What does the filtrate contain?
What is the reaction of the solution on litmus?

c. To a few cubic centimeters of the solution add a little of a solution of sodium carbonate.

What is precipitated?
What remains in the solution?

d. Through another portion of the filtrate pass carbon dioxide until the precipitate which first formed (what is it?) is redissolved. Heat this clear solution.

What occurs?

Experiment 83

a. Place a few pieces of gypsum in a dry test tube, and heat it.

What change takes place, and what is the substance left in the tube after heating?

b. Place some plaster of Paris in a small dish, and add to it such an amount of water that when the powder is well stirred into the water the mass will be rather thick and coherent. Press down upon this a coin. When the plaster of Paris has hardened, remove the coin, and note the clear impression of it which has been formed.

Experiment 84 (80)

Pulverize 1 g. of potassium chlorate in a mortar, add to it 9 g. of strontium nitrate, and thoroughly mix the two substances. Empty out the contents of the mortar on a piece of paper, wash the mortar thoroughly, wipe it dry, and grind in it 3 g. of shellac. Add this to the substances on the paper, and carefully mix them with as little friction as possible. (*Do not grind the shellac in the mortar with the other ingredients. An explosion would result.*) Place the mixture on a brick or tile and ignite.

If properly prepared, it should burn with a brilliant red flame.

Experiment 85

a. Place 5 cc. of a solution of barium chloride in a test tube, warm it, and add slowly dilute sulphuric acid until no further precipitate is formed.

What is this precipitate?

Is it soluble in dilute hydrochloric acid?

b. Repeat the above experiment, using a solution of sodium carbonate in place of the dilute sulphuric acid.

Experiment 86

Place a few crystals of magnesium sulphate in a dry test tube and heat it.

Is all of the water removed by gentle heating?
At what temperature does this take place?

Experiment 87

a. Burn a piece of granulated zinc by holding it in the small hot flame of the blast lamp.

What is formed?
What is the color of the flame?

b. To a solution of zinc sulphate add ammonium sulphide.

What is the color and composition of the precipitate?

c. Add ammonium sulphide to a solution of a cadmium salt.

What is the color and composition of the precipitate?

Experiment 88

a. Mix 2 g. of mercuric sulphide with an equal weight of powdered lime and heat the mixture in a hard-glass tube until the residue assumes a dark yellow color.

What collects in the upper part of the tube?
What is left in the lower part?

Shake out this residue and add to it dilute hydrochloric acid. Note the odor of the escaping gas.

What is it?

b. Bring a bit of gold leaf into contact with a small drop of mercury 3 to 4 mm. in diameter. Press and stir the mercury with a match until the gold has thoroughly amalgamated. Place the amalgam in a small porcelain crucible, cover it, and heat in the hood until the mercury is volatilized.

What remains behind?
What practical use is made of this procedure?

c. Add a solution of sodium chloride to solutions of mercurous nitrate and mercuric chloride.

What results in each case?

Experiment 89 (81)

a. Dissolve 2 g. of mercuric chloride in 50 cc. of water, and add this to a solution in water of 2.5 g. of potassium iodide. Shake thoroughly. Pour a small amount of the precipitate into a few cubic centimeters of a solution of mercuric chloride. Add another portion of the precipitate to a solution of potassium iodide.

What is the result in each case?

Filter the third portion and dry the precipitate.

What is its color?

Heat a little of it gently in a porcelain evaporator and then allow it to cool.

What are the changes in color and to what are they due?

Experiment 90

Place some aluminum foil or wire in a test tube and add a few cubic centimeters of a strong solution of potassium hydroxide.

What gas is evolved, and what becomes of the aluminum?

Experiment 91 (82)

a. Dissolve a few crystals of alum in water and add ammonium hydroxide.

What is the precipitate?

b. Filter and wash it, and then pour upon it while it still remains upon the filter paper 2 or 3 cc. of a litmus solution.

Can the color of the litmus now be washed out?

What is the substance called that is here formed?

What practical use is made of this property of aluminum hydroxide?

Experiment 92 (83)

To a solution of an aluminum salt add one or two drops of potassium hydroxide. Note the result. Then continue the addition of the reagent and note the result of this further addition.

Repeat the experiment using ammonium hydroxide in place of potassium hydroxide.

Is the result the same?

Experiment 93

a. Melt some metallic tin in a small crucible and pour it into a pan of water from a height of two or three feet.

What form does the tin assume?

b. Place a few pieces of granulated tin in a test tube, add 5 cc. of concentrated hydrochloric acid, and heat. When the tin is dissolved add the solution (what salt of tin has been formed?) to a solution of mercuric chloride.

What is formed?

Explain the action.

Experiment 94

Provide a test tube with a well-fitting two-hole stopper. Through one pass a glass tube reaching nearly to the bottom of the test tube and connect it with a drying bottle containing strong sulphuric acid (Fig. 37). Through

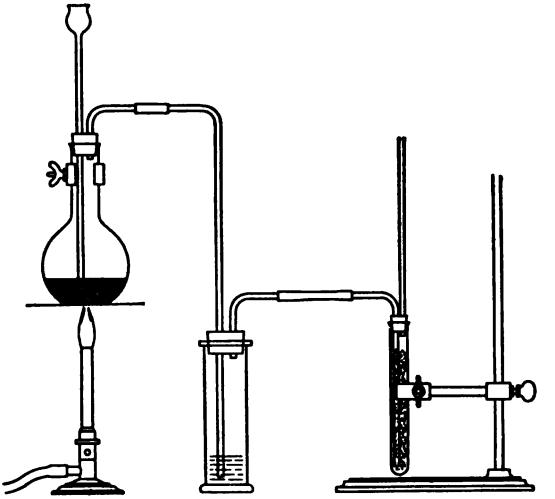

FIG. 37.

the other opening in the stopper introduce a glass tube ending just below the stopper and extending into the opening of the hood or projecting out of doors. Fill the test tube with granulated tin. Insert the stopper and then pass chlorine through the drying bottle into the test tube.

What is the liquid which collects at the bottom of the tube?

Is heat evolved in this reaction?

What are the white fumes which escape from the end of the exit tube?

Experiment 95

a. Place some metallic tin in an evaporating dish, add strong nitric acid, and warm gently in the hood.

What is the action on the tin and what substance is formed?

What is the action on the nitric acid?

b. After the action is complete and all of the tin has been transformed, warm gently in the hood to drive off the excess of nitric acid, and then treat a small portion of the residue with a strong solution of sodium hydroxide.

What is the result and what is formed?

Experiment 96

a. Scrape or cut a piece of lead and note the color of the metal before it oxidizes.

b. To separate portions of about 1 cc. each of a solution of lead nitrate add hydrogen sulphide, dilute sulphuric acid, potassium chromate, hydrochloric acid, potassium hydroxide, and sodium carbonate.

What is formed in each case?
Which precipitate is dissolved if the solution is warmed and which one if the reagent is added in excess?

Experiment 97 (84)

Suspend a piece of zinc in a solution of lead acetate or lead nitrate.

What is the result?

Experiment 98

Pour some concentrated hydrochloric acid upon a little lead dioxide.

What is the reaction?
What other dioxide behaves in a similar manner with strong hydrochloric acid?

Experiment 99 (85)

a. Dissolve about 1 g. of powdered antimony in aqua regia (HNO_3 + HCl), and dilute the solution with water until it just begins to turn turbid. Divide it into two portions, and saturate one with hydrogen sulphide.

What is the precipitate that is formed?
What is its color?

b. Filter, dry the precipitate, and heat gently in a glass tube.

What change does it undergo?

c. To the second portion of the solution add ammonium sulphide.

What is the precipitate which has formed?

Add more ammonium sulphide.

What is the result?
What substance has been formed by this further addition?

Add dilute hydrochloric acid.

What is precipitated?

Experiment 100 (86)

Dissolve 1 or 2 g. of powdered bismuth in nitric acid, and divide the solution into two parts. Set one aside to crystallize.

What are the crystals which separate?

To the other portion add a considerable quantity of water.

What results, and what is formed?

Experiment 101

Add ammonium hydroxide to a solution of a chromium salt.

What is the color of the precipitate which forms, and what is its composition?

What change in its composition would result if it were highly heated?

Experiment 102

Mix 3 g. of dry sodium carbonate with 3 g. of powdered potassium nitrate. Place the mixture in a small crucible,

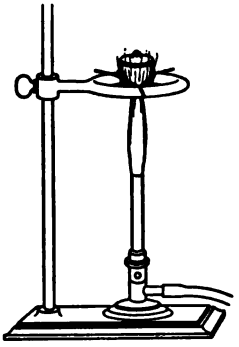

FIG. 38.

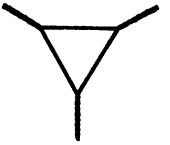

FIG. 38 A.

cover it, and heat it on a triangle (Fig. 38) until it fuses. Then add to the molten mass 1 g. of powdered chromic oxide, and keep the whole in gentle fusion for three or four minutes. Allow it to cool.

What is now the color of the substance?

Place the crucible in 30 cc. of warm water, allow it to stand for some minutes, and then filter.

To what is the color of the filtrate due?

Add dilute sulphuric acid until the solution has an acid reaction.

What change in color results?

What substance has been formed?

Add ammonia until the solution is alkaline.

Is a precipitate produced?

Experiment 103 (87)

a. To 5 cc. of a solution of potassium dichromate add 1 cc. of concentrated sulphuric acid. Heat to boiling and add alcohol, in small portions, until the color of the solution is completely changed to green. Cool and add ammonia.

What is precipitated?

Explain fully the changes that the potassium dichromate has undergone.

b. Dissolve 4 g. of potassium dichromate in 15 cc. of warm water. Cool the solution until crystals just begin to separate, and then pour it slowly and with constant stirring into 23 cc. of concentrated sulphuric acid in a beaker standing in cold water.

What separates out?
What is its color and composition?

Experiment 104

Precipitate a lead solution by adding a solution of potassium dichromate.

What is the precipitate?
What is its color and commercial name?

Collect it on a filter paper, wash it, transfer some of it to an evaporating dish, add 2 or 3 cc. of a solution of potassium hydroxide, and boil.

What change results?
What is the product called?

Experiment 105 (88)

a. Mix 5 g. of potassium hydroxide with 3 g. of potassium chlorate, and heat the mixture in a crucible until it fuses. Then add 5 g. of powdered manganese dioxide and keep in gentle fusion for three or four minutes. Cool and dissolve in cold water. Filter.

What is the color of the filtrate?

b. Pass carbon dioxide through the filtrate until it takes on a pink or purple color.

What is the substance which now is present in the solution?

c. Place about 5 cc. of a solution of ferrous sulphate in a test tube, acidify it with dilute sulphuric acid, and then add to it, drop by drop, the filtrate obtained above. Describe accurately the color changes which are seen.

When does the color become permanent?

Experiment 106 (89)

a. Place about half a gram of finely divided iron or piano wire in a 100 cc. flask provided with a single-hole stopper which carries a glass tube drawn out at the upper end to a very small opening. Pour upon the iron in the flask about 30 cc. of dilute sulphuric acid (1:4), insert the stopper, and heat gently on the wire gauze until the iron is completely dissolved. Remove the stopper and immediately add ammonium hydroxide.

What is the color and composition of the precipitate?

b. Now add to the contents of the flask strong nitric acid, drop by drop, until the precipitate is dissolved. Heat the flask until the liquid assumes a yellow tint.

What change has taken place?

c. Transfer a small portion of the solution to a test tube, and add a few drops of a solution of potassium sulphocyanate.

What is the result?

d. To the remainder of the solution add ammonium hydroxide once more.

What is the color of the precipitate?
What is it?

Experiment 107 (90)

Prepare a dilute solution of cobalt chloride (1 g. in 10 cc. of water) and with a pen write upon a sheet of white paper. Allow the latter to dry.

Is a color distinctly visible?

Now warm the paper.

Do the characters now become easily legible, and what is their color?

Experiment 108 (91)

Fuse a piece of platinum wire about 6 cm. long into a glass tube and bend the outer end to a small loop. Moisten the loop, pick up upon it some powdered borax, and heat in the flame until the borax forms a clear bead.

Precipitate about 1 cc. each of solutions of nickel and cobalt with potassium hydroxide. Filter each. Touch the borax first to some of the cobalt hydroxide and fuse again in the flame.

What is now the color of the bead?

Break off the bead, clean the wire thoroughly and prepare a second borax bead. This should be colorless like the first. Pick up upon this bead a little of the nickel hydroxide and fuse again.

What is the color of the bead?

Experiment 109 (92)

Dip a bright iron nail into a solution of copper sulphate.

What remains upon the nail?
What has happened to the iron?

Experiment 110

Dissolve about 5 g. of copper sulphate in 100 cc. of water and add 5 cc. of strong nitric acid. Place this solution in a beaker and pass through it a current from a galvanic battery, connecting the positive pole of the battery with an anode consisting of a copper wire and the negative pole with a cathode of carbon. A piece of electric light carbon may be used here as the cathode.

What is deposited upon the carbon?
Can the deposit easily be wiped off?
Is the copper wire affected at all?

Experiment 111 (93)

a. Pulverize 3 g. of crystalline copper sulphate and heat it in a dry test tube.

What is set free?
What remains behind?
What is the color of the residue?

Moisten it.

What is now its color?

b. Add 10 cc. of water and warm until solution is complete. Cool the solution.

To 5 cc. add a cold solution of sodium hydroxide.

What are the color and composition of the precipitate?

Boil the solution.

What are now the color and composition of the precipitate?

c. To the other portion of 5 cc. of the solution of copper sulphate add a few drops of ammonium hydroxide and then add several cubic centimeters of the same reagent. Describe and explain the various changes.

Experiment 112

a. Dissolve a piece of metallic copper in nitric acid and evaporate carefully to dryness.

What is the color of the residue?

Remove a small portion and ascertain whether it is soluble in water.

b. Heat the remainder of the substance in the dish until it loses its blue color and turns black.

What is given off?
What remains in the dish?
Is this residue soluble in water?

Experiment 113

a. Dissolve a silver ten-cent piece in nitric acid (1 : 1).

What salts are now present in the solution?

Evaporate the solution to dryness in a clean evaporating dish and heat the residue until it has entirely lost its blue color. Cool. Add 30 cc. of pure water and warm. Filter.

What substance is in solution in the filtrate?

Pour 2 or 3 cc. of this filtrate into a test tube and add ammonium hydroxide. No blue color should appear. Why not? (If it does, evaporate to dryness and heat the residue once more.) Dilute the remainder of the filtrate to 100 cc. To 5 cc. of the solution add hydrogen sulphide.

What is formed?

b. To another portion of 20 cc. add hydrochloric acid and then, without filtering, add ammonium hydroxide. Then add sufficient nitric acid to neutralize the free ammonium hydroxide. Describe in full the various changes which have occurred.

c. Collect upon a filter paper the precipitate which formed upon the addition of the nitric acid. Wash it with water and then make a small hole in the apex of the paper, place a test tube under the filter, and wash the precipitate into the tube. Allow the precipitate to settle, and then pour off the water above it. Now add about 5 cc. of a saturated solution of sodium thiosulphate.

What is its effect upon the silver chloride?

Reserve the remainder of the silver solution for use in Experiments 114 and 115.

Experiment 114 (95)

Dip a small filter paper into some of the silver nitrate solution from the preceding experiment and pin it up in a dark cupboard. When dry, place upon it some opaque object (a leaf or fern gives a pretty result) and expose to the light until the paper around the object has become black. Place the paper in a saturated solution of sodium thiosulphate, and after ten minutes' time pour off the thiosulphate and replace it by pure water. Rinse four or five times in water and then carefully remove and dry.

What appears upon the paper?
Explain the chemistry of the procedure.

Experiment 115 (94)

Precipitate the remainder of the silver nitrate solution from Experiment 113 with hydrochloric acid. Filter and wash the precipitate. Transfer the silver chloride while still moist to a porcelain dish or test tube. Add one or two pieces of granulated zinc and cover the mixture with

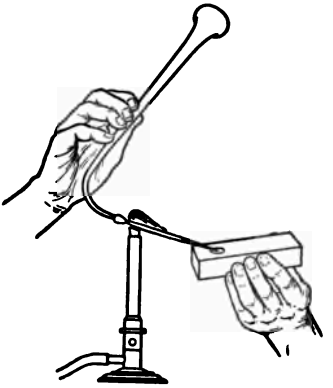

Fig. 39.

dilute sulphuric acid. When the zinc has been entirely dissolved, filter and wash with dilute sulphuric acid and then with water. Mix the finely divided silver with sodium carbonate and potassium carbonate and fuse on charcoal with a blowpipe flame (Fig. 39). A globule of pure silver should be formed.

Experiment 116

Dissolve 1 g. of silver nitrate in distilled water and dilute to 60 cc. To 50 cc. of this solution add dilute ammonium hydroxide until the precipitate which first forms *almost* disappears on stirring. Filter and dilute with water to 83 cc.

Dilute with water the remaining 10 cc. of the silver nitrate solution to 83 cc. and heat to boiling. Add to this boiling solution .14 g. of Rochelle salts (potassium sodium tartrate), and allow the boiling to continue for a short time, when the precipitate which has formed will assume a gray color. Filter the solution while it is still hot.

Clean the inside of a small glass flask by rinsing with a solution of potassium hydroxide, then with concentrated nitric acid, then with water, and finally with alcohol. Place it in an inverted position and allow it to dry thoroughly. Mix equal volumes of the two solutions prepared as above and pour this mixture at once into the clean flask. Allow it to stand untouched for some minutes, when a brilliant deposit of silver should appear on the inner walls.

Experiment 117 (97)

a. Add a few drops of a solution of potassium ferrocyanide to a solution of ferrous sulphate.

What is the color of the precipitate which forms?

b. Repeat this experiment, using ferric chloride in place of the ferrous sulphate. Describe the result.

c. Add a solution of potassium ferricyanide to ferrous sulphate and ferric chloride.

How is it possible to distinguish between a ferrous salt and a ferric salt by the aid of these reagents?

Experiment 118 (98)

Mix 50 cc. of water with 25 cc. of strong alcohol.

Can the mixture be ignited?

Place the liquid in a flask provided with a thermometer and connected with a condenser, as shown in Fig. 40.

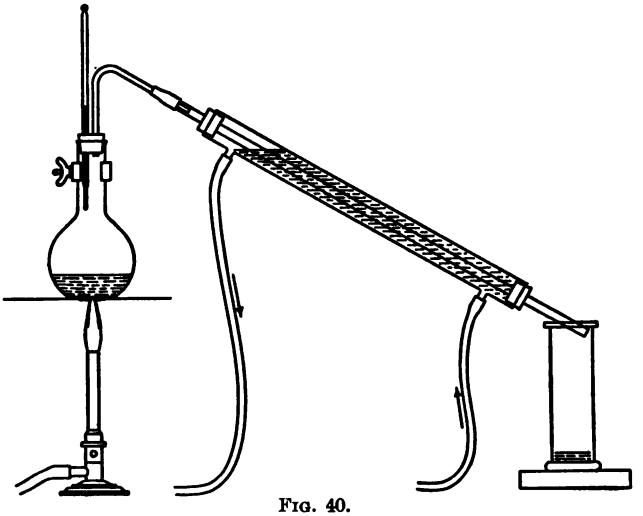

FIG. 40.

Heat to boiling, and distill off one third of the liquid in the flask.

At what temperature did the liquid begin to pass over into the receiver?

What was the temperature shown by the thermometer when the distillation was stopped?

Why was it higher toward the end than at the beginning?

Does the liquid in the receiver have the odor of alcohol?

Try to light 1 or 2 cc. of it with a match.

Experiment 119

Prepare chromic acid as described under Experiment 103, *b*, using one quarter of the amounts there given, and to this add a few cubic centimeters of alcohol. Notice the odor.

What is the action upon the alcohol?
Does the solution change in color?
To what is this due?

Experiment 120 (100)

a. Place in a 250 cc. flask 10 g. of sugar, and add 100 cc. of nitric acid (1 : 1). Heat gently in the hood or out of doors until brown fumes are given off, and then remove the flame. When violent action has ceased, boil the liquid down rapidly to about 20 cc., and then cool the flask under the tap.

What are the crystals which separate?

b. Dissolve them in a little warm water and recrystallize them.

c. Dissolve some of these crystals in water, and add this solution to a few cubic centimeters of a dilute solution of potassium permanganate which has been acidulated with a few drops of dilute sulphuric acid.

Is the permanganate decolorized?

What other substance acts similarly upon potassium permanganate?

Experiment 121 (101)

Add 1 cc. of strong sulphuric acid to 100 cc. of water, and heat in a flask to boiling. Grind 2 g. of starch with sufficient water to form a thin paste, and pour this into the acid so slowly as not to check the boiling. Continue the boiling for one hour, and then add precipitated or powdered chalk until all of the free acid has been neutralized.

How can this be ascertained?

Filter off the insoluble substance (what is it?), and evaporate the filtrate to small bulk on a water bath. An

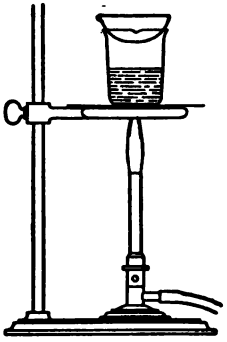

FIG. 41.

improvised water bath is shown in Fig. 41. The dish containing the solution to be evaporated rests upon a beaker in which water is kept boiling.

Is the residue in the dish sweet to the taste?

Does it give a blue color with tincture of iodine? (See Experiment 57, *b*.)

What does the result indicate?

Determination of the Weight of Oxygen which unites with Magnesium to form Magnesium Oxide

Experiment 122

Clean and dry a small porcelain crucible with its cover and weigh the two together. Weigh as accurately as the balance will permit a piece of magnesium ribbon of about 100 mg. in weight. Place the magnesium in the crucible, cover the crucible, and heat on a triangle in the manner shown in Fig. 38. When the magnesium has been entirely converted to magnesium oxide, allow the crucible to cool and weigh it again. The increase in weight is due to the oxygen that has united to the magnesium.

Calculate the theoretical increase in weight from the weight of the metallic magnesium which was used.

How does this compare with the result obtained in the experiment?

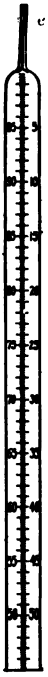

FIG. 42.

APPARATUS

For the quantitative experiments to be described on the following pages there will be needed a graduated glass tube of the form shown in Fig. 42, and the level-bulb *B* (Fig. 43), about 60 mm. in diameter. The rest of the necessary apparatus will usually be included in the students' set or can easily be procured or made, as the case may be, by either the teacher or student. The measuring tube is calibrated in fifths of a cubic centimeter, beginning with the end of the capillary *e* and reading up and down. The calibration extends to the end of the tube. The contents of the tube from the end of the capillary to the wide end is 55 cc. The tube is approximately 18 mm. in diameter and 33 cm. long.

Determination of the Amount of Oxygen in the Air

Experiment 123

Thoroughly clean the measuring tube *A* and level-bulb *B* (Fig. 43) and insert *A* in the clamp in an upright position. Put the pinchcock *e* on the rubber tube at the upper end of *A* close to the end of the capillary tube. Close the pinchcock *S* close to the end of the glass tube *M*. *M* should end flush with the upper side of the rubber stopper *T*. Dissolve 1 gr. of pyrogallol in 10 cc. of water, and 20 gr. of potassium hydroxide in 50 cc. of water. With the aid of a small funnel introduce about 20 cc. of the potassium hydroxide solution into the bulb *B* through its open end. Now add the solution of pyrogallol and finally pour in the remainder of the potassium hydroxide solution. Remove *M* with the stopper *T* from the end of the measuring tube. Hold the end of *M* over a beaker and open *S* to allow the solution in *B* to fill the rubber tube and *M* completely. It is well to allow about 10 cc. of the liquid to run out from the

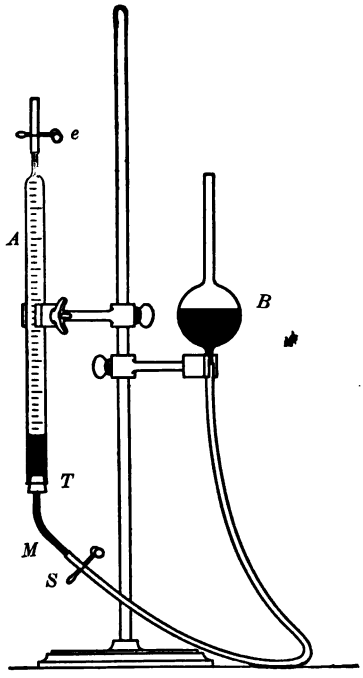

Fig. 43.

end of *M*. Close *S* and firmly insert the rubber stopper into the lower end of *A*. Note the point on the calibration at which the upper side of the stopper *T* now stands. The air in *A* will have been somewhat compressed by the insertion of the stopper. Bring it to atmospheric pressure by opening the pinchcock *e* for a moment. Now lift the bulb *B* as high as the rubber tube will permit and open *S*. Some of the solution of the alkaline pyrogallol will flow into the measuring tube. Close *S*, place *B* in its clamp, grasp the lower end of *A* with the thumb and fingers of the right hand, and remove *A* from the clamp. Take hold of the capillary *e* with the left hand and turn *A* into a horizontal position, tilting it backward and forward so as to cause the solution to come into contact with all of the air in *A*. Place *A* again in the clamp, raise *B* and open *S*, thus bringing more of the solution into the measuring tube. Shake the tube *A* again. Insert *A* in the clamp, open the pinchcock *S* and raise the level-bulb *B* until the liquid stands at the same height in the bulb and the measuring tube. Read the gas volume that has been absorbed. Repeat the shaking and reading until no further decrease in the volume of air in *A* takes place. Calculate the percentage of oxygen in the air from the measurements obtained.

Determination of the Volume of Hydrogen set Free by Treating a Weighed Amount of Zinc with Hydrochloric Acid

Experiment 124

The zinc is placed in a small wide-neck bottle *C* (Fig. 44) about 7 cm. high and 3½ cm. in diameter. The bot-

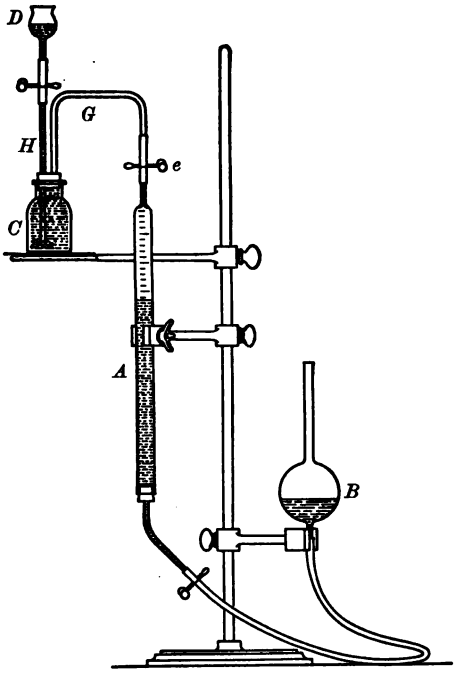

Fig. 44.

tle is fitted with a two-hole rubber stopper, through one opening of which is inserted the bent capillary tube *G*. One end of this capillary ends flush with the lower side

of the stopper of the bottle, and the other end is inserted in the rubber tube attached to the capillary *e* on the measuring tube. Through the other opening of the rubber stopper passes a glass tube *H*, which is drawn out and bent upward at the lower end to prevent hydrogen gas rising through the tube and escaping through the funnel tube *D* which is attached to the upper end of *H* by a piece of rubber tubing.

The experiment is carried on as follows: Clean the bottle *C* and place in it a weighed piece of pure zinc, together with a small piece of platinum wire which serves to hasten the evolution of the hydrogen. Fill the bottle nearly full of water, and insert the rubber stopper carrying the glass tubes *H* and *G*. *G* is not as yet connected with the measuring tube *A*. Pour water into the funnel tube *D*, and open the pinchcock on *H* until all the air has been driven out of the bottle through *G*, and *G* is itself full of water. Be sure that the tube *H* is also full of water. Close the pinchcock on *H*. Having connected the measuring tube and the level-bulb in the manner shown in the figure, fill *B* with water and raise it, with the pinchcock on *e* open, until *A* and the rubber tube at its upper end are full of water. Now close the pinchcock on *e* and place *B* in its supporting clamp. Insert the end of the capillary tube *G* into the rubber tube on *e*. The whole apparatus should now be full of water from the funnel tube *D* to the level-bulb *B*. Place *B* below the lower end of *A* and open the pinchcock on *e*. Pour out what water there may be in *D*, and fill *D* with concentrated hydrochloric acid. The evolution of hydrogen from the zinc may be hastened by adding a few drops of platinic chloride to the hydrochloric acid instead of placing platinum wire in the bottle *C*. Open the pinchcock on *H* and allow some of the acid

to flow into *C*. The evolution of hydrogen will begin at once, and the gas will pass over through *G* into the measuring tube *A*. Allow the action to continue until the zinc is dissolved and no more gas is set free. Hydrochloric acid should be allowed to enter through *H* from time to time if the evolution of hydrogen becomes slow. When the action is complete, pour water into *D* and open the pinchcock on *H*. The water will now flow through *C* and *G* into *A*, driving all the gas before it. When *G* is full of water, close the pinchcock on *e* and raise the level-bulb *B* until the water in the bulb and the measuring tube *A* stands at the same height. Now read the volume of gas in *A*, and at the same time note the temperature and the height of the barometer. The thermometer from which the temperature is read should hang close to the measuring tube *A*. Reduce the volume of hydrogen gas to that volume which it would occupy under standard conditions, that is, when dry and at a temperature of 0° and 760 mm. pressure, and then compute the weight of the hydrogen. Calculate the weight of the hydrogen which should be given off by the amount of zinc that was used.

How do the results agree?

Calculate also the volume of hydrogen, under standard conditions, which should be given off by the zinc.

How does this volume compare with the corrected volume of hydrogen that was found?

Determination of the Volume of Oxygen set Free from a Weighed Amount of Potassium Chlorate and the Weight of the Potassium Chloride that is Formed

Experiment 125

Fill the bulb *B* (Fig. 45) with water and raise it until *A* is filled to the top. Then close the pinchcock *e*. Bend

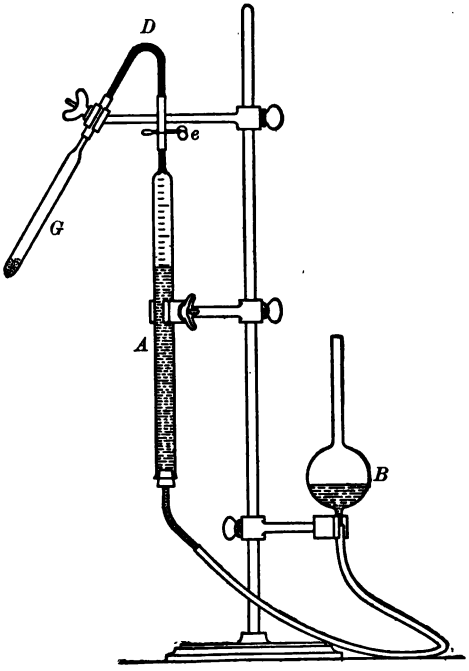

Fig. 45.

a piece of capillary tubing into the shape shown in *D*. Seal one end of a piece of hard glass tubing one centime-

ter in diameter and about 12 cm. long by heating it in the flame of a blast lamp, and draw out the other end until it has about the same diameter as the capillary *D* (see *G*, Fig. 45). Wash and dry this tube thoroughly. Pulverize some potassium chlorate in a mortar and dry it by heating for at least an hour in an air bath. An air bath may be improvised by using the apparatus shown in Fig. 41, employing, in place of the beaker there shown, a beaker with the bottom cut off. A more serviceable device consists of a cylinder of sheet iron, open at both ends, and 5 cm. in diameter and 6 cm. high. This can easily be made by a tinsmith. The broken beaker or iron cylinder is placed on the wire gauze as in Fig. 41, and the substance is placed in the small dish on top of the beaker or cylinder. The flame should be quite low, so that the substance will not be heated much above 100° C. Weigh the hard glass tube empty, and then introduce into it about 0.130 g. of the dried potassium chlorate and weigh again. Connect the tube with the capillary *D* by means of a piece of rubber tubing, and then insert the other end of *D* into the rubber tube at the top of *A*. In doing this be sure that the rubber tube above the pinchcock *e* contains no water, and when inserting the end of *D* into the tube, squeeze the tube flat between the thumb and finger so as to drive out the air in it. By making the connection in this manner the air in *D* and *G* will have approximately the pressure of the outside air. Now open the pinchcock *e*, and set it down on the capillary tube so that it remains open. Lower *B* until it stands below the lower end of *A*, and heat the potassium chlorate in *G* with a Bunsen burner. In heating *G* hold the burner in the hand and move it backward and forward so that *G* will gradually be warmed. Oxygen will be set free and will pass over

into *A*. Toward the end of the operation, heat the end of *G*, where the substance is, for about a minute with the full flame of the burner. Stop the heating and allow the whole apparatus to stand until it has assumed the temperature of the room. Bring the water in *B* and *A* to the same level and measure the oxygen that has been set free. Read the thermometer and barometer, and compute the volume which the oxygen would occupy under standard conditions.

A liter of oxygen weighs 1.43 g. Calculate the weight of the corrected volume of oxygen. Close the pinchcock *e*, remove *G*, and weigh it with the potassium chloride which it now contains. Deduct the weight of the tube to ascertain the weight of the potassium chloride.

How does this last result agree with the calculated amount of potassium chloride which should have been obtained from the potassium chlorate?

How does the weight of the oxygen agree with the weight of oxygen which should have been set free from the potassium chlorate?

How does the volume of the oxygen agree with the volume of the oxygen which should have been set free from the potassium chlorate?

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How does the volume of the oxygen agree with the volume of the oxygen which should have been set free from the potassium chlorate?

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How does the weight of the oxygen agree with the weight of oxygen which should have been set free from the potassium chlorate?

How does the volume of the oxygen agree with the volume of the oxygen which should have been set free from the potassium chlorate?

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How does this last result agree with the calculated amount of potassium chloride which should have been obtained from the potassium chlorate?

How does the weight of the oxygen agree with the weight of oxygen which should have been set free from the potassium chlorate?

How does the volume of the oxygen agree with the volume of the oxygen which should have been set free from the potassium chlorate?

Determination of the Volumetric Composition of Ammonia

Experiment 126

Clean and dry the measuring tube *A*, place the rubber tube and pinchcock on the capillary, and insert it upright in the clamp. Place in the lower end of *A* a one-hole rubber stopper carrying a bent capillary tube *M* (Fig. 46). *M* ends flush with the upper side of the stopper and its outer end is provided with a short piece of rubber tubing and a pinchcock. Connect *M* with an apparatus furnishing chlorine gas, and with the pinchcocks *S* and *e* open pass chlorine into *A* until all air is displaced. Disconnect the chlorine generator and close *S* and *e*. Place a pinchcock *V* about 2 cm. from the lower end of the rubber tube *C* which is joined to the level-bulb *B*. Fill *B* with dilute sulphuric acid (1 : 4). Open the pinchcock *V* and allow some of the acid to flow out through the rubber tubing and displace the air in it. Then close the pinchcock. Make sure that no air remains in the rubber tube. This

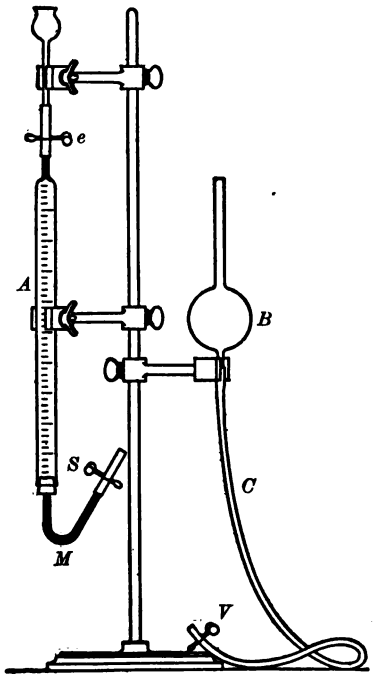

Fig. 46.

may be done by squeezing the tube between the thumb and finger next to the pinchcock and running this pressure along the tube up to the bulb. Now quickly slip off the short piece of rubber tubing and pinchcock that are on the end of *M* and slip over *M* the end of the tube *C*. If *C* is filled to the end with sulphuric acid, this will drive the acid into the capillary *M* and will fill the capillary. The chlorine in *A* will then be under slight excess pressure, and this is relieved by opening the pinchcock *e* for an instant. Insert into the end of the rubber tube above *e* the short funnel tube used in Experiment 124. Support the funnel tube with a clamp and pour into it 5 cc. of strong ammonium hydroxide. Remove the air from the stem of the funnel tube by pushing a small stirring rod down into it and moving the rod quickly up and down in the stem. The apparatus will now be in the position shown in Fig. 47. Now admit some of the ammonium hydroxide into *A* by quickly pressing the pinchcock *e* *just for an instant.* Wait a few moments and then add a little more of the ammonium hydroxide. When *nearly* all of it has been introduced, remove the funnel tube, grasp the measuring tube by the capillary, remove it from the clamp, and slant it two or three times so as to allow the ammonia to flow throughout its length. Again bring it into

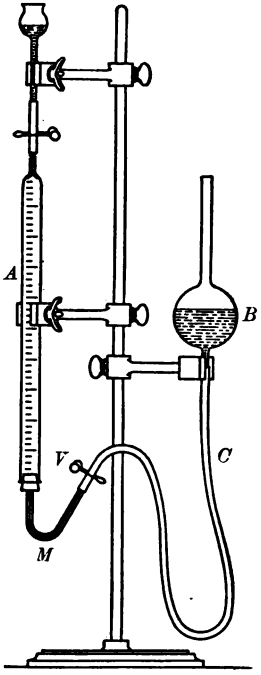

FIG. 47.

an upright position in the clamp and allow the apparatus to stand for about five minutes.

When chlorine acts upon ammonia, it unites with the hydrogen of the ammonia and sets free the nitrogen according to the equation:

$$3\,Cl_2 + 2\,NH_3 = 6\,HCl + N_2.$$

The hydrochloric acid that is formed reacts with some of the excess of ammonia to form ammonium chloride. The remainder of the ammonia in excess must now be removed before the gas still remaining in *A* can be measured, and this is accomplished by means of the sulphuric acid in *B*. To do this, open *V* (Fig. 47), and allow the acid to rise as far as it will in *A*. Then close *V*, remove *A* from the clamp, and tilt it backwards and forwards a few times to complete the absorption of the free ammonia by the acid. Place *A* again in the clamp, open *V*, and bring the acid in *A* and *B* to the same height. Read the volume of the gas now present in *A*.

From the above equation it is seen that three volumes of chlorine (six atoms) act on two molecules of ammonia and there remains behind one volume (two atoms) of nitrogen. When chlorine unites with hydrogen to form hydrochloric acid, one volume of chlorine unites with one volume of hydrogen. Hence, the three volumes of chlorine in the equation must have united with three volumes of hydrogen originally in combination with nitrogen in the ammonia, that is, the three volumes of hydrogen must originally have been united to the nitrogen which now remains in *A*.

If the experiment has been correctly performed, it will be found that this nitrogen is one third of the original volume of the chlorine. Hence, in ammonia, NH_3, one volume of nitrogen is united to three volumes of hydrogen.

Titration of a Known Amount of Sodium Hydroxide with Hydrochloric Acid to determine the Strength of the Acid

Experiment 127

Clean the measuring tube *A* and place it with the large end upward in the clamp. Attach to the capillary a piece of rubber tubing and pinch-cock, and insert in the rubber tubing a short piece of glass tubing *C*, drawn down to an opening about 1 mm. in diameter (Fig. 48).

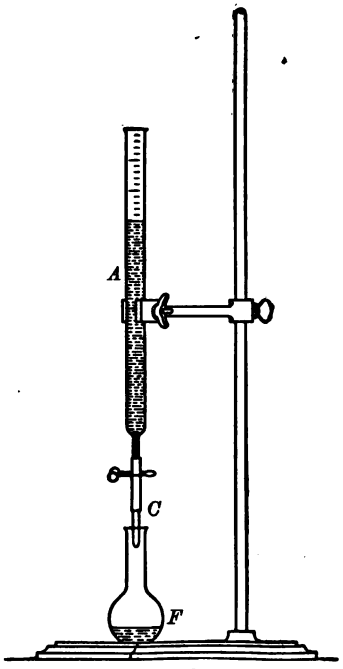

Fig. 48.

Place 40 cc. of distilled water in a 200 cc. flask, and support the flask in a slanting position by placing its neck in a clamp. Clean a small watch glass and weigh it on the balance. Place upon this a piece of clean sodium of from 100 to 140 mg. in weight and weigh again. The difference between the two weights gives the weight of the sodium. The sodium is cleaned by removing it from the petroleum in which it is kept, pressing it with filter paper to free it from the adhering oil, and then shaving its sides with a knife to remove the scale. The metal will of course oxidize in con-

tact with the air, but its weight can, nevertheless, be found with an accuracy sufficient for the purpose of this experiment. Thoroughly dry the inner wall of the neck of the small flask containing the 40 cc. of water by wiping it with a cloth wrapped around a pencil, and then throw into the flask the piece of sodium. The sodium will decompose some of the water and will change to sodium hydroxide. Just as the action ceases, the hydrogen, which has been set free in the flask, may be ignited, and a slight explosion may result. This can do no harm, since the mouth of the flask is open. Remove the flask from the clamp, and shake it gently to cause the water to dissolve any sodium hydroxide that may remain clinging to the glass. Then add to the liquid one drop of a litmus solution. Fill the measuring tube *A* with dilute hydrochloric acid (one part by volume of concentrated hydrochloric acid to about 40 parts by volume of water). Open the pinchcock and allow some of the acid to run out so that the rubber tube and small glass tube may be completely filled. Then carefully open the pinchcock until the acid in *A* stands at the 50 cc. mark. Now bring the flask *F*, containing the solution of sodium hydroxide, under the tip of the burette (see Fig. 48), and carefully add the hydrochloric acid little by little, with occasional shaking of the contents of the flask until the solution in the flask just turns red. Now read on the burette the volume of hydrochloric acid which has been used in neutralizing the sodium hydroxide.

Calculate from the weight of metallic sodium which was taken the weight of hydrochloric acid contained in the volume of acid that was used.

Calculate the weight of hydrochloric acid in each cubic centimeter of the solution of hydrochloric acid.

Clean and dry a small porcelain evaporating dish about 7 cm. in diameter and weigh it. Place it upon the little water bath shown in Fig. 41 and pour into the dish the solution in the flask. Rinse out the flask once with a few centimeters of water, and add this water to the contents of the dish. Evaporate this solution of sodium chloride to dryness. Replace the beaker of water by the broken beaker or iron cylinder described under Experiment 125, and heat the dish over this air bath until the salt is thoroughly dry. The flame of the Bunsen burner should be about 3 cm. high, and the top of the flame should be about 5 cm. below the gauze on which the beaker or iron cylinder rests. Allow the dish to cool and weigh it again.

What is the weight of the sodium chloride that has been formed by neutralizing the sodium hydroxide with the acid?

Knowing the weight of the sodium chloride, calculate the weight of the sodium which it contains.

How does this result agree with the weight of metallic sodium that was taken?

From the weight of the sodium chloride calculate the strength of the hydrochloric acid.

How does this result agree with that obtained in the manner above directed?